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Expansion mechanism of sulfate attack on cement-treated aggregates under freeze–thaw cycles

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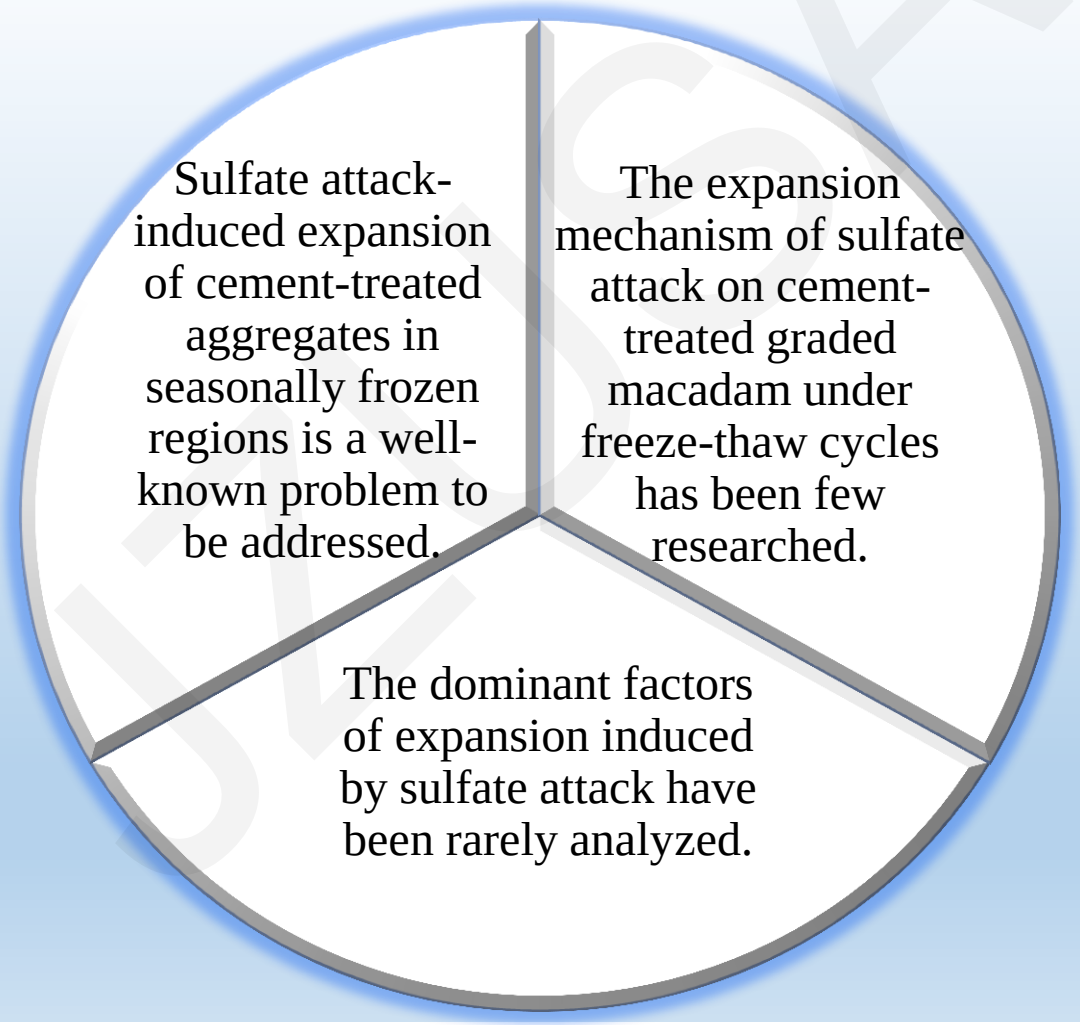
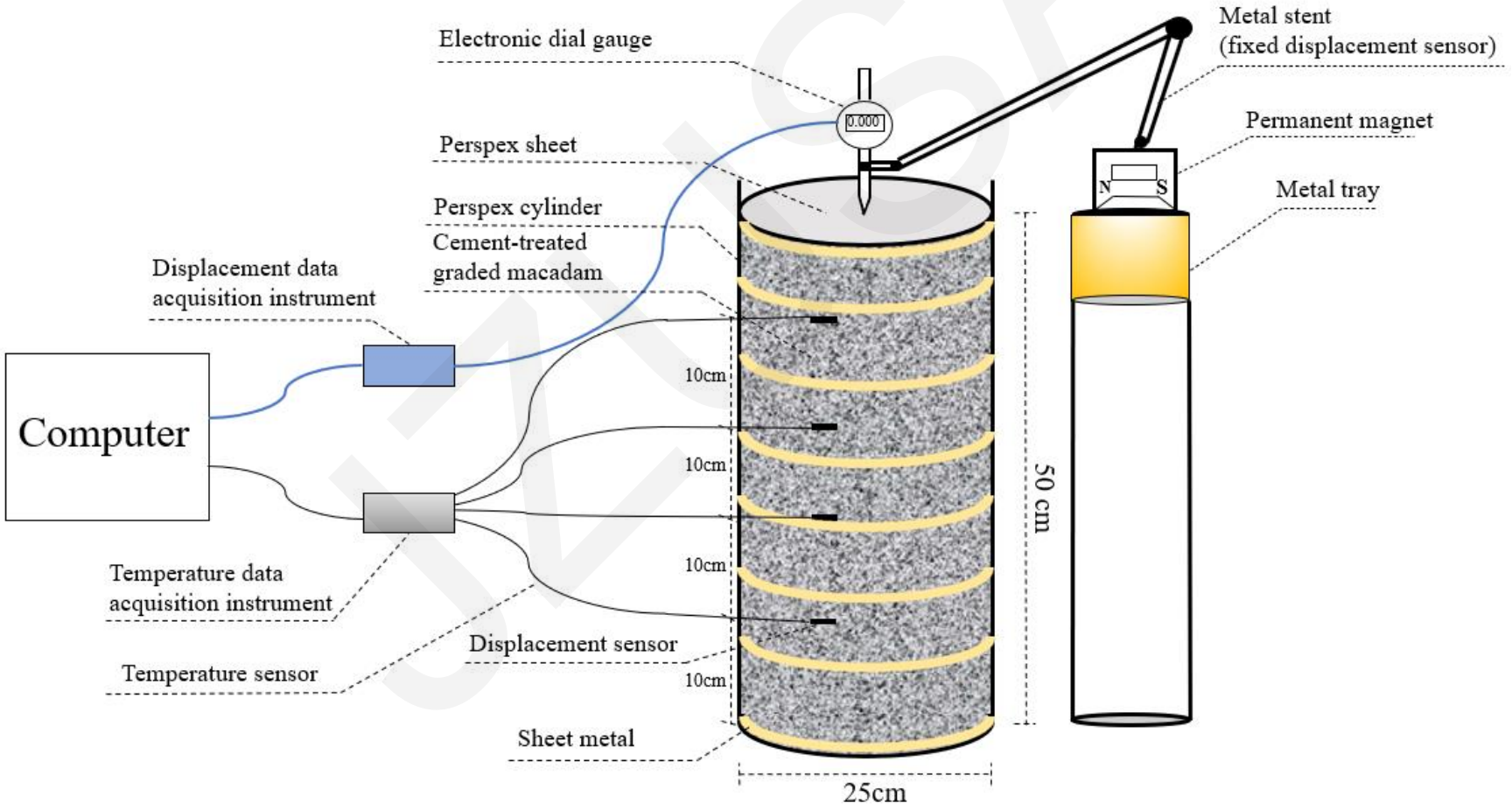
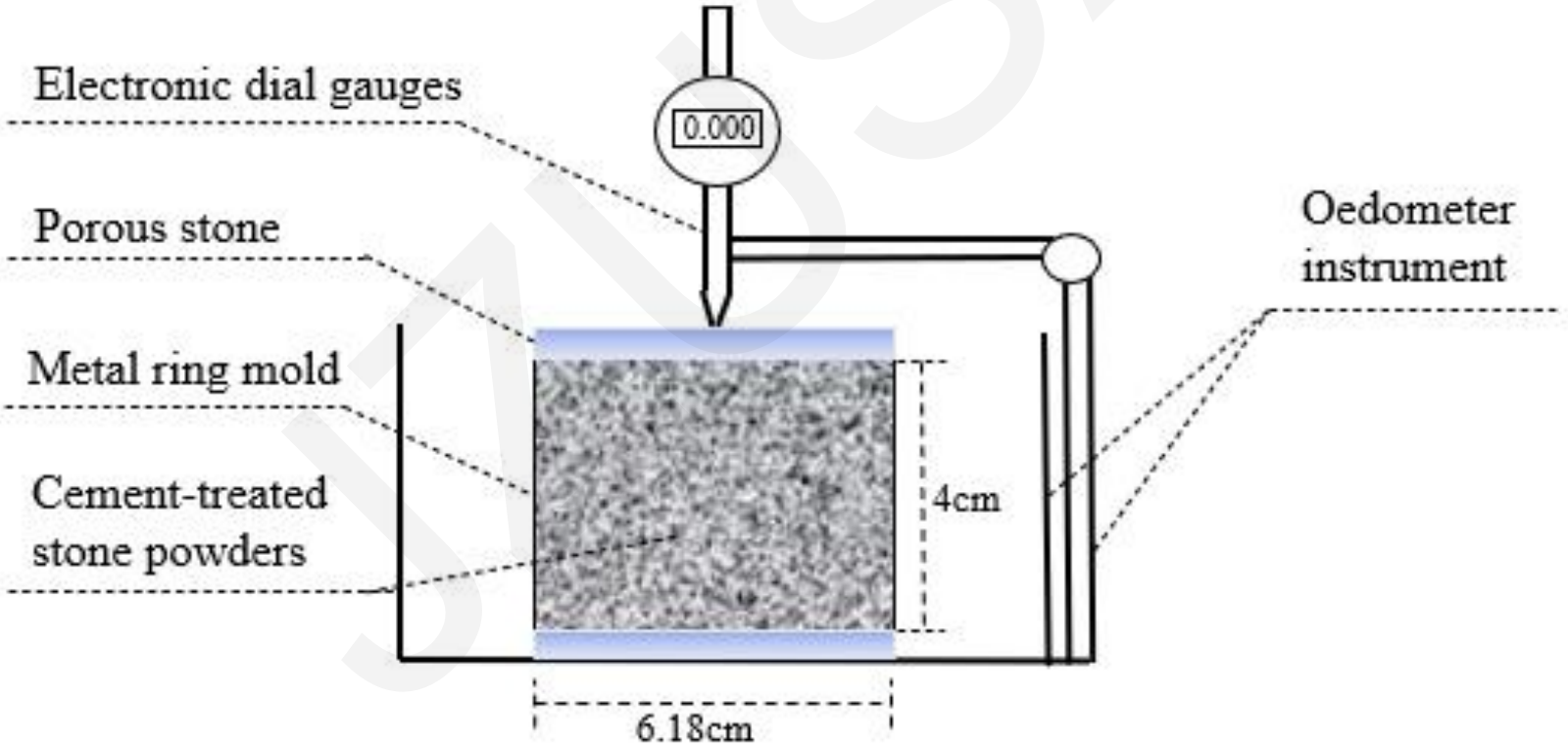
Research background



Details for swelling tests device of graded macadam samples



Details for swelling tests device of stone powders samples



Conclusions

- Under FT cycles, the deformation of samples with 1% content sulfate was larger than the samples with 1% content sulfate and 3% content cement. The samples with 3% content cement only experienced slight deformation. The deformation of samples with 1% content sulfate (or with 1% content sulfate and 3% content cement) increase rapidly within the initial 7 FT cycles (or 3 FT cycles), then increase slowly.
- Under the same FT cycles, the lower the FT temperature, the greater the recoverable and unrecoverable strains of samples with 1% content sulfate (or with 1% content sulfate and 3% content cement). For samples only with 1% content sulfate, the unrecoverable strains are greater than the recoverable strains beyond 7 FT cycles, while the initial cycles are smaller than that of recoverable strains. For samples with 1% content sulfate and 3% content cement, the unrecoverable strains are significantly greater than recoverable strains.

Conclusions

- For sulfate attack aggregates (without cement), the expansion is mainly induced by the periodic frost heave and salt expansion, and salt migration. And about 44%~56% of the deformation was unrecoverable. For sulfate attack cement-treated aggregates, the expansion is mainly induced by chemical attack and salt migration. And about 70% of the deformation was unrecoverable.
- In the process of sulfate attack cement-treated aggregates, the abundant needle-like crystals (2~5μm) were observed through SEM tests.
- In this study, the dominant factors of expansion induced by sulfate attack have been studied through the recoverable deformation and unrecoverable expansion. This paper provides a new viewpoint for the research on the mechanism of sulfate attack. In fact, the expansion induced by sulfate attack are influenced by the simultaneous couplings among frost heave, salt expansion, salt migration, and the generation of swelling minerals. In the future, the mechanism of expansion induced by sulfate attack can be studied more comprehensively through the multi-field coupling numerical analysis.