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Elastoplastic behavior of frozen sand－concrete interfaces under cyclic shear loading

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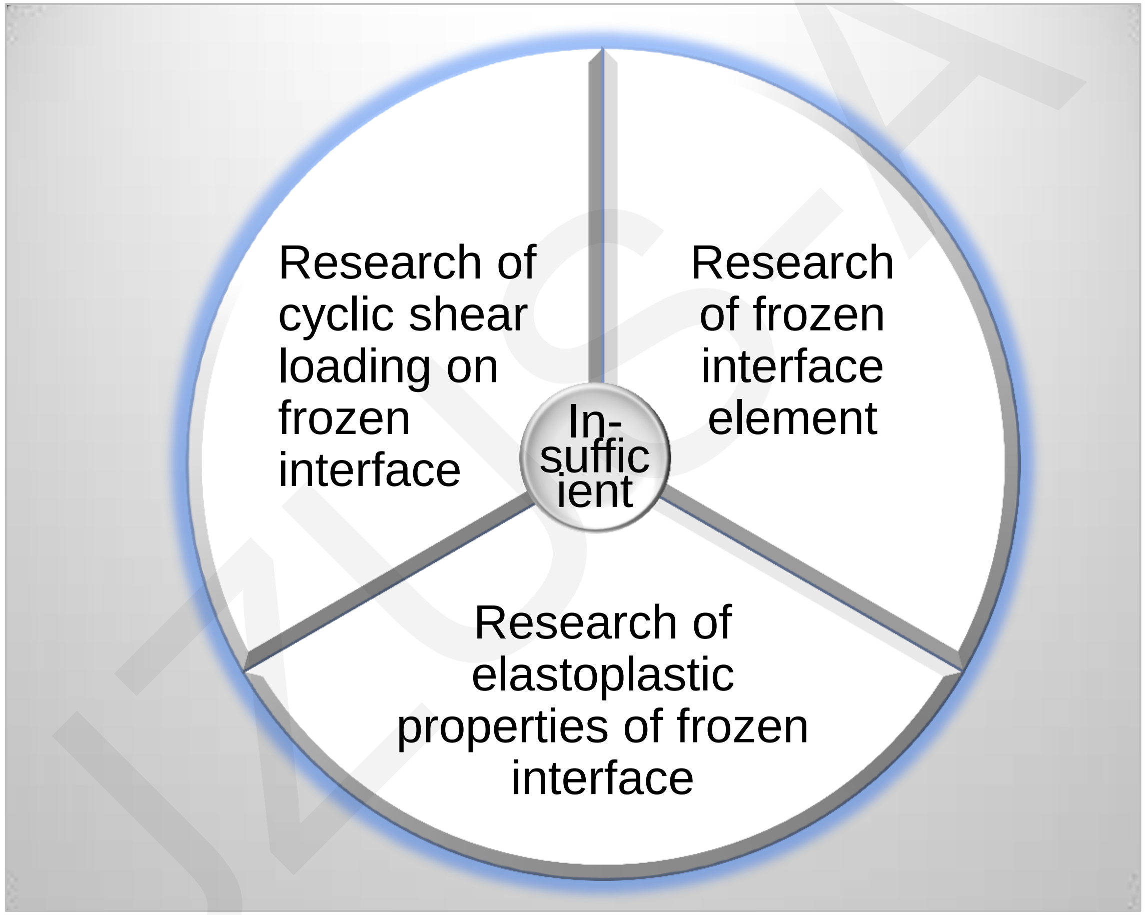
Research background

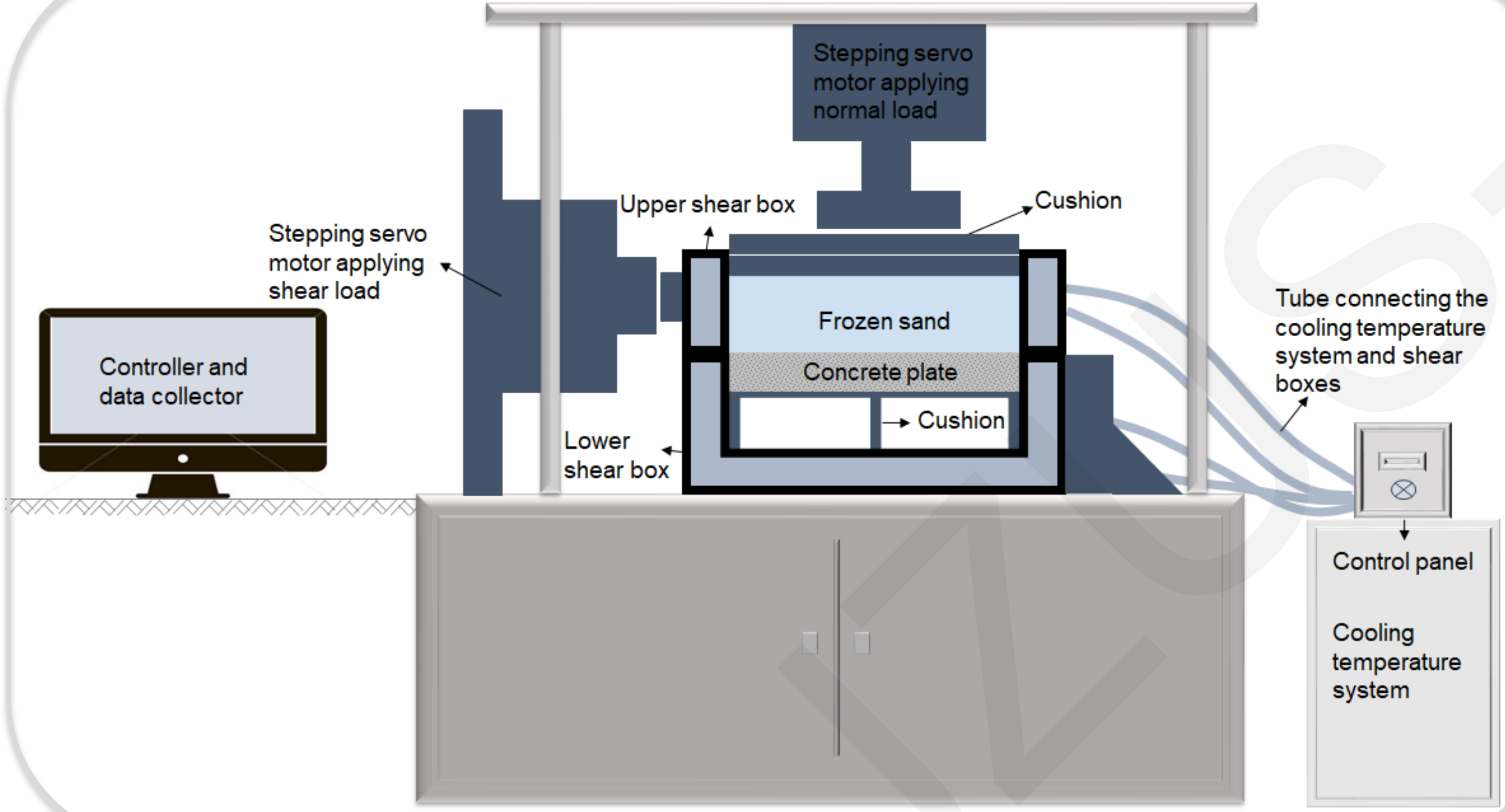


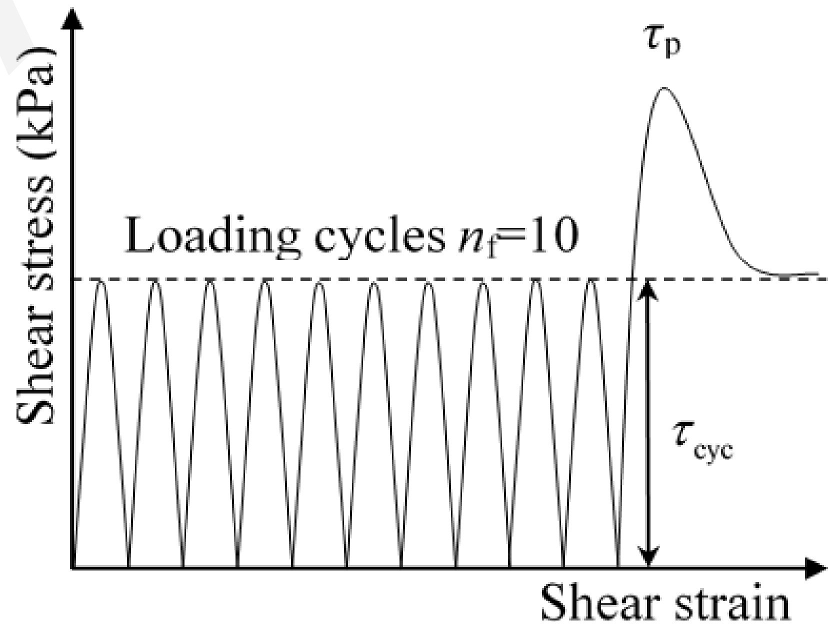
Test Case

Boundary conditions	Initial normal stress σ_n (kPa)	Temperature T (°C)	Cyclic shear stress amplitude $k = \tau_{cyc} / \tau_p^{Mon}$	Moisture content (%)
Constant normal stress Constant normal height	100 200 300	-2 -5 -8	0.2 0.5 0.8	Saturated

- τ_{cyc} is the cyclic shear stress
- τ_p^{Mon} is the peak shear stress of the frozen sand–concrete interface under monotonic shear loading with the same conditions as the cyclic shear test

Test apparatus and cyclic shear loading





Conclusion

- The initial elastic shear modulus and cyclic elastic shear modulus increase when the initial normal stress increases and temperature decreases. However, the cyclic-loading amplitude has a negligible influence on the elastic shear modulus (including the initial elastic shear modulus and cyclic elastic shear modulus) under cyclic shear stress. The cyclic elastic shear modulus fluctuates within a small range when the cyclic-loading amplitude increases, indicating that the cyclic-loading amplitude has a slight influence on the cyclic elastic shear modulus.
- The relationship among the elastic shear modulus under monotonic shear stress, initial elastic shear modulus and cyclic elastic shear modulus under cyclic shear stress can be described by an exponential function.
- Under CNL and CNH, the plastic shear strain of frozen sand–concrete interfaces increases and the accumulation increment of the frozen sand–concrete interfaces decreases, when the loading cycles increases. Moreover, the lower the temperature, the lower the increment in accumulated plastic shear strain, which increases with normal stress at a given cyclic-loading amplitude. The lower the initial normal stress, the less the increment in accumulated plastic shear strain, which increases with negative temperature at a given cyclic-loading amplitude.
- The effects of the initial normal stress, negative temperature, and cyclic-loading amplitude on the accumulated plastic shear strain and accumulated plastic volumetric strain are significant. The accumulated plastic shear strain and accumulated plastic volumetric strain increase with increasing initial normal stress and increasing cyclic-loading amplitude and decreasing temperature in the same loading cycle.

Conclusion

- The test results show that an exponential function can describe the relationship between the direction of accumulated plastic strain increment and the accumulated plastic shear strain. We analysed the relationships between the direction of accumulated plastic strain increment and the initial normal stress, negative temperature, and cyclic-loading amplitude in detail.
- When the initial normal stress increases, the temperature decreases, and the cyclic-loading amplitude increases, under CNL and CNH, and the peak shear stress increases significantly. The experimental results confirmed these behaviors. The critical shear stress increased with the initial normal stress under both boundary conditions. However, the critical shear stress is independent of the negative temperature and cyclic-loading amplitude under both boundary conditions.
- The peak shear stress under CNH is higher than that under CNL, and the critical shear stress under CNH is lower than that under CNL at a given initial normal stress. The accumulated plastic shear strain under CNL is higher than that under CNH.
- The elastoplastic behaviour of the frozen sand–concrete interface in this study is consistent with certain behavioural aspects of the unfrozen sand–concrete interface. However, the ice cementation between the soil and concrete results in specific mechanical behaviors of the frozen soil–concrete interface, which indicate that an appropriate constitutive model should be established for frozen sand–concrete interfaces under cyclic shear loading.