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Pile foundation of high-speed railway undergoing repeated groundwater reductions

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Background

- **The running mileage of high speed railway in China has reached more than 36,000 km**

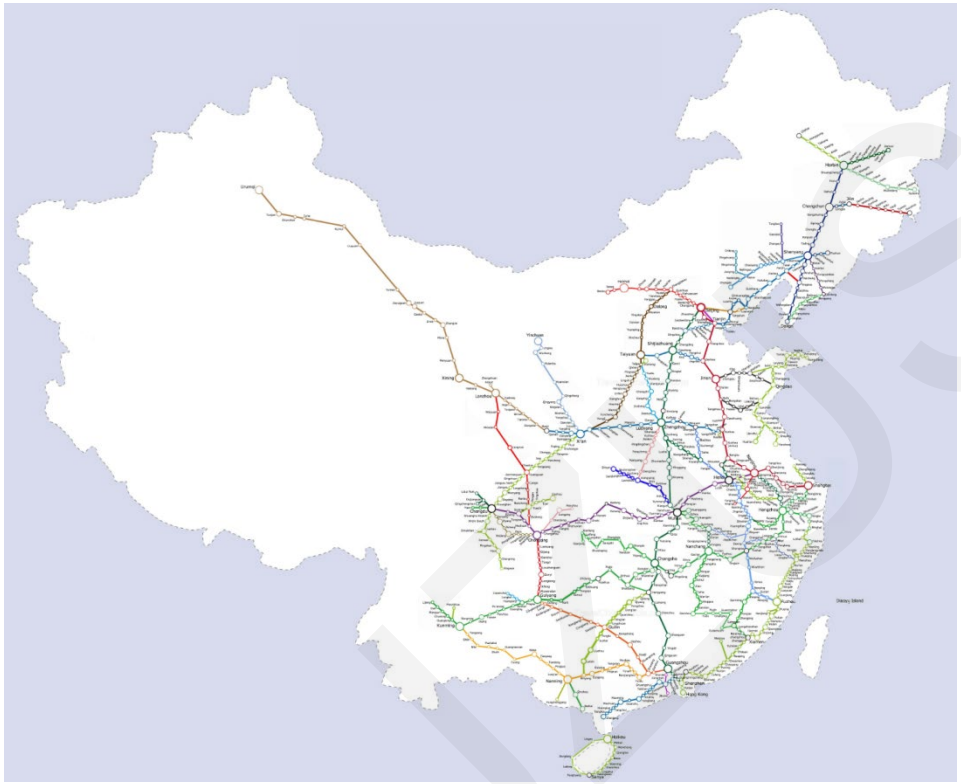


Fig. 1 High speed railway operation map



Fig. 2 High speed railway

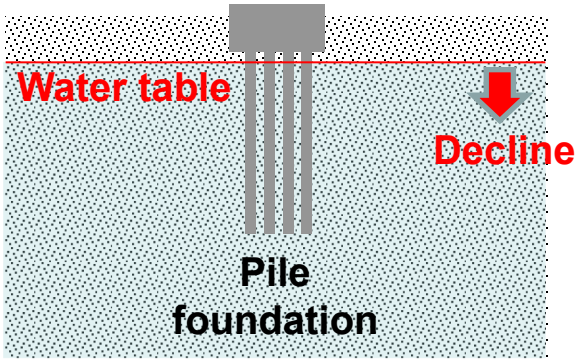
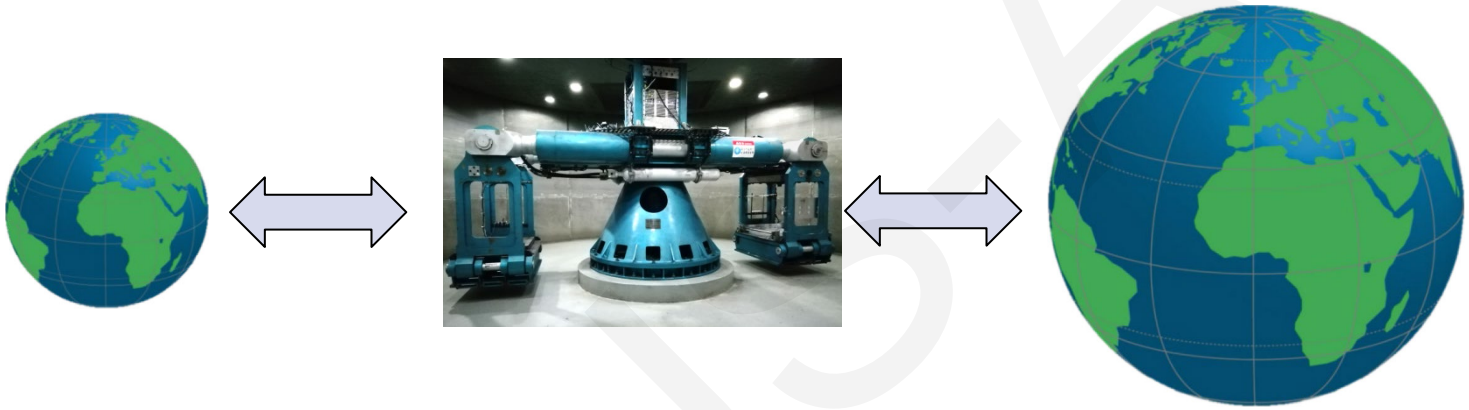


Fig. 3 Water table decline

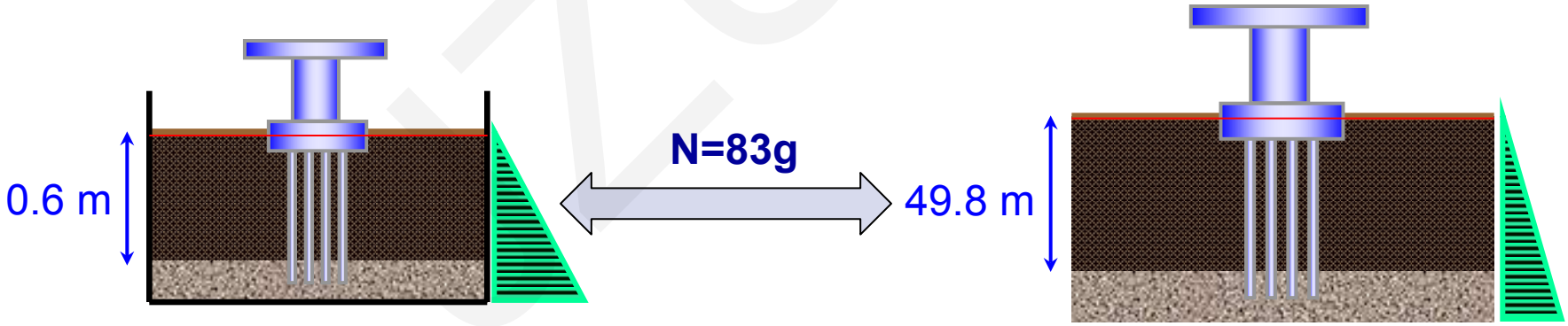
Recently, massive use of groundwater has induced excessive ground settlements in developed regions, where there is usually a dense high-speed railway network.

Methodology

- The responses of multiple pile groups in silty soils subjected to groundwater declines were investigated by centrifuge tests



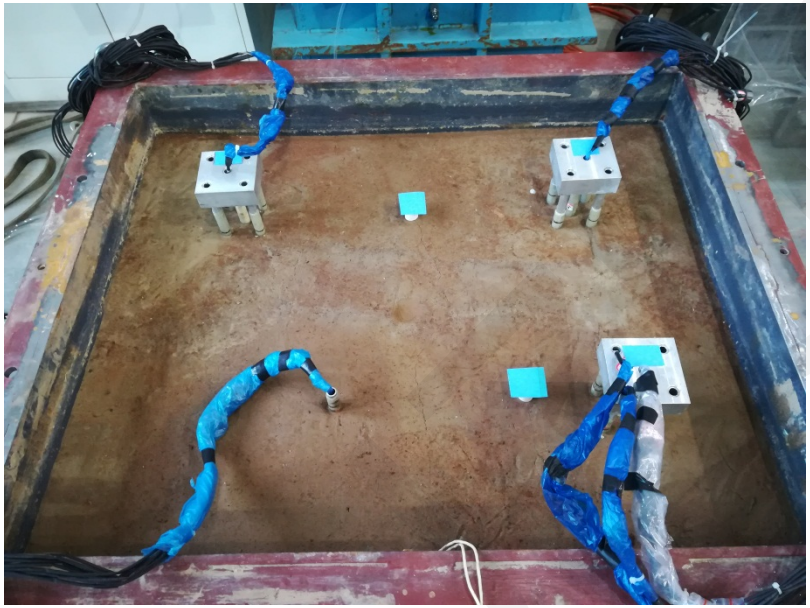
Hyper-gravity (ng) Centrifuge facility Normal gravity (1g)



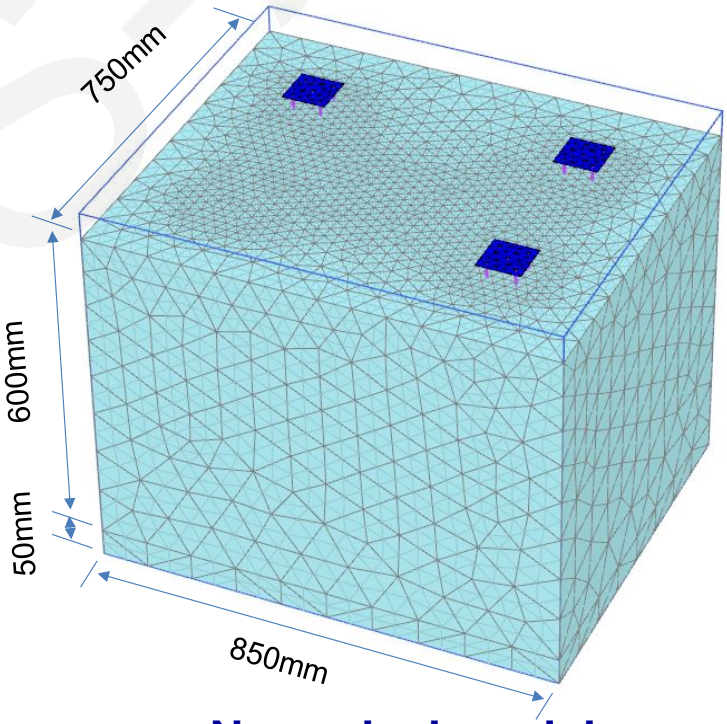
Model Prototype

Methodology

- The responses of multiple pile groups in silty soils subjected to groundwater declines were also investigated by the numerical approach referring to the test model



Testing photo



Numerical model

Results and Conclusions

- As the water table declined, the inconsistent displacement of the soil relative to the pile resulted in a rise in skin friction on the pile, which increased the pile settlement and axial forces accordingly.
- The position of the neutral point of the pile was not sensitive to groundwater decline and remained at a depth of 0.7 times the pile length. A longer pile presented a larger maximum axial force at the neutral point and the coefficient, β, for evaluating the pile's axial force decreased with increasing pile length.
- Nevertheless, the incremental percentage of the maximum axial force decreased as pile length increased. Specifically, after 8.9 m of groundwater decline, those of the central pile in the 20 m, 30 m and 40 m pile groups increased by 40.3%, 36.3% and 27.4%, respectively.
- Soil settlement varied significantly in the annular area of 10 times pile diameter around the pile group, which increased with the distance to the pile group under the same groundwater decline.
- The Cyclic Load Ratio and Static Load Ratio determined the settlement development of a railway pile foundation during a long-term service period. The drop in groundwater level not only caused additional settlement due to soil reconsolidation, but also increased the Static Load Ratio to influence the settlement development disadvantageously.
- A design method of railway pile foundation considering groundwater decline was proposed and applied to an actual case. According to the change in β versus the water table decline from the centrifuge test, the minimum bearing capacity of pile was approximately 60.9% larger than that without consideration of 2 m groundwater decline.

