Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

Compressibility and hydraulic conductivity of sand-attapulgite cut-off wall backfills

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Cite this as: Wen-bing Zhang, Wen-bo Rao, Lei Li, Ye Liu, Shuai Wang, Ke Jin, Fang-wen Zheng, 2019. Compressibility and hydraulic conductivity of sand-attapulgite cut-off wall backfills. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 20(3):218-228.

https://doi.org/10.1631/jzus.A1800548

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Research Background

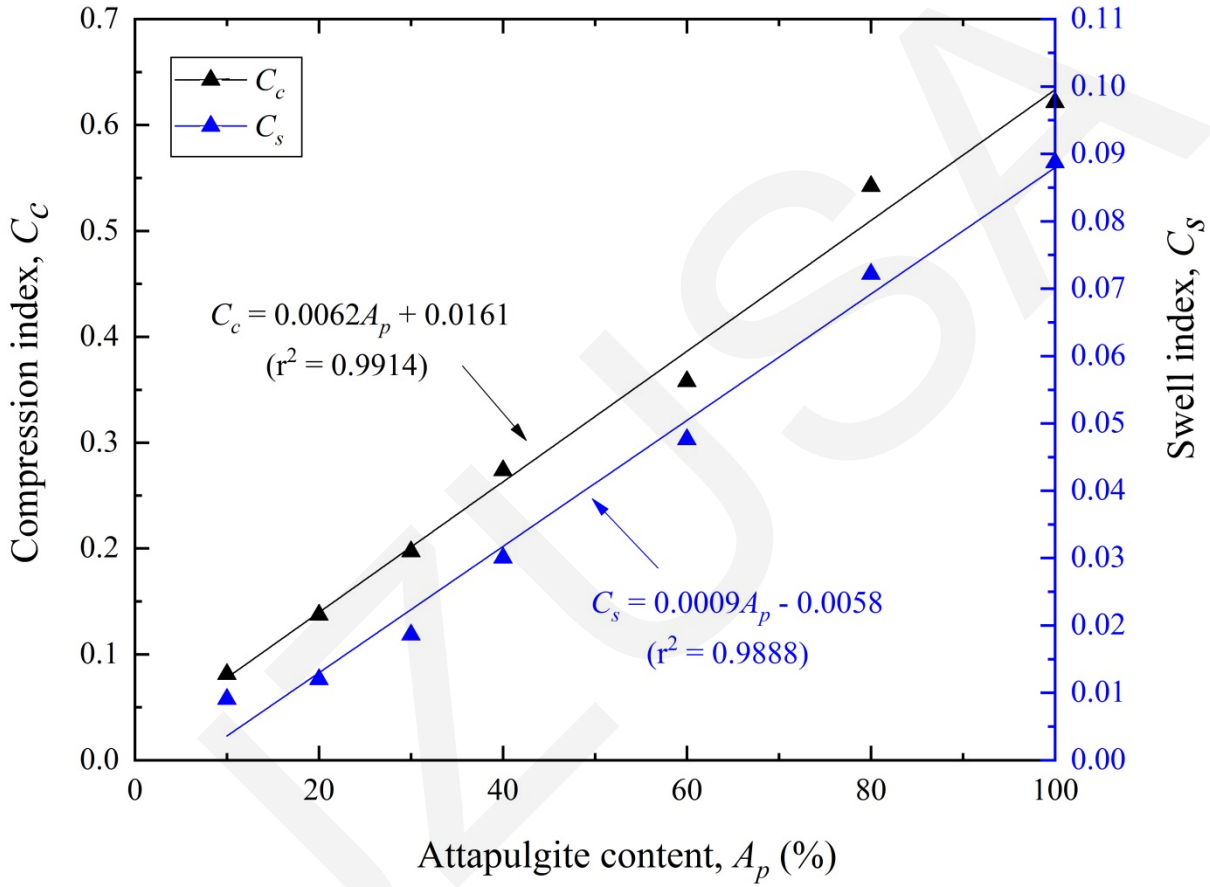
- According to the statistics of the Professional Committee of Urban Domestic Refuse Treatment of China Association of Environmental Protection Industry (2017), the production of municipal solid wastes (MSWs) approached **200 million** tons in 2015, and in China more than **60%** of MSWs are disposed of in landfills.
- Most landfills constructed early in China are relatively simple and have **no seepage control systems** (Xu et al., 2016). Leachates in the landfills contain a wide range of harmful substances released from MSWs, **contaminating the surrounding soils and groundwater systems** through lateral leakage (Xie et al., 2009; Laner et al., 2012).
- It is necessary to **construct vertical cut-off walls** to prevent the leakage of leachates from the landfills (Evans et al., 1995; Sharma and Reddy, 2004; Zhu et al., 2014).
- Attapulgite has been considered as a substitute for bentonite in cut-off wall backfills (Ryan, 1987; Day, 1994; Stern and Shackelford, 1998).

Research Purposes

- Explore the effect of different attapulgite additions on the compressibility and hydraulic conductivity of sand-attapulgite cut-off walls;
- Develop empirical methods, based on laboratory data in the framework of the Kozeny-Carman equation, for predicting the hydraulic conductivity of sand-attapulgite backfills.

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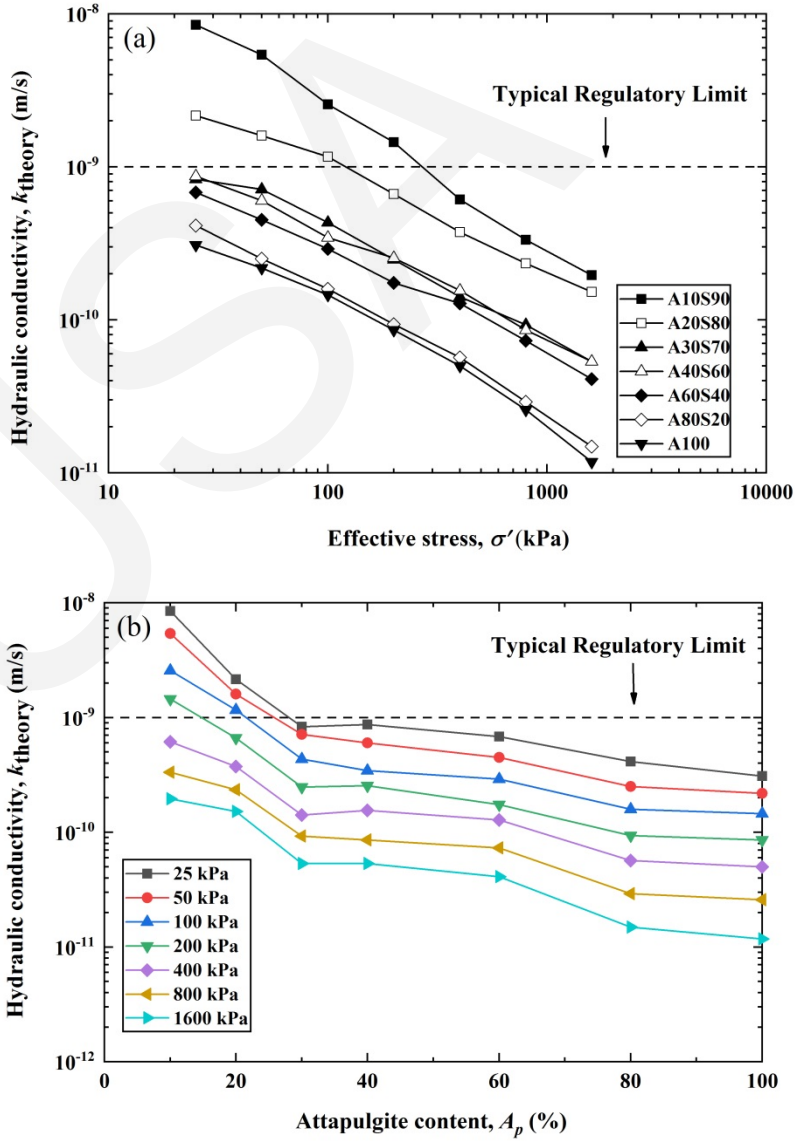
Results



Variation of compression index (C_c) and swelling index (C_s) versus attapulgite content

Results

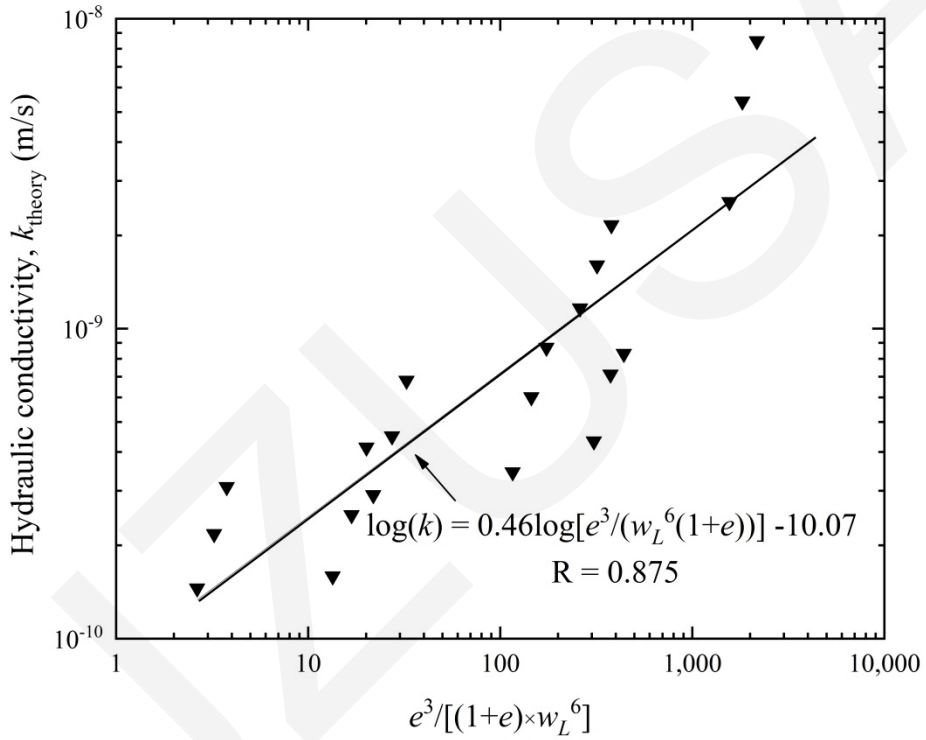
Computed hydraulic conductivity (k_{theory}) changes as a function of (a) effective consolidation stress (σ') and (b) attapulgite content, respectively for sand-attapulgite backfills



Results

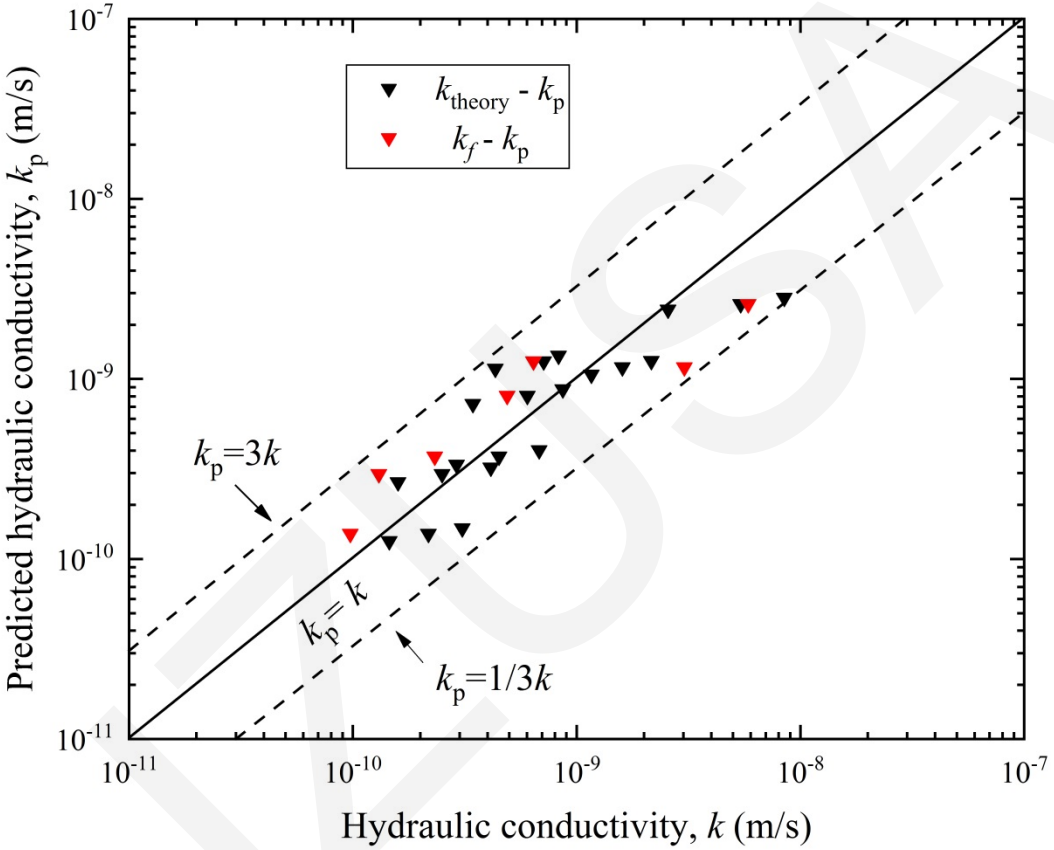
Prediction of hydraulic conductivity (k_p)

Method 1



Relationship between calculated hydraulic conductivity k_{theory} calculated based on Terzaghi consolidation theory and $e^3/(w_L^6 \times (1+e))$ of all backfills at an effective consolidation stress (σ') between 25 and 100 kPa

Results

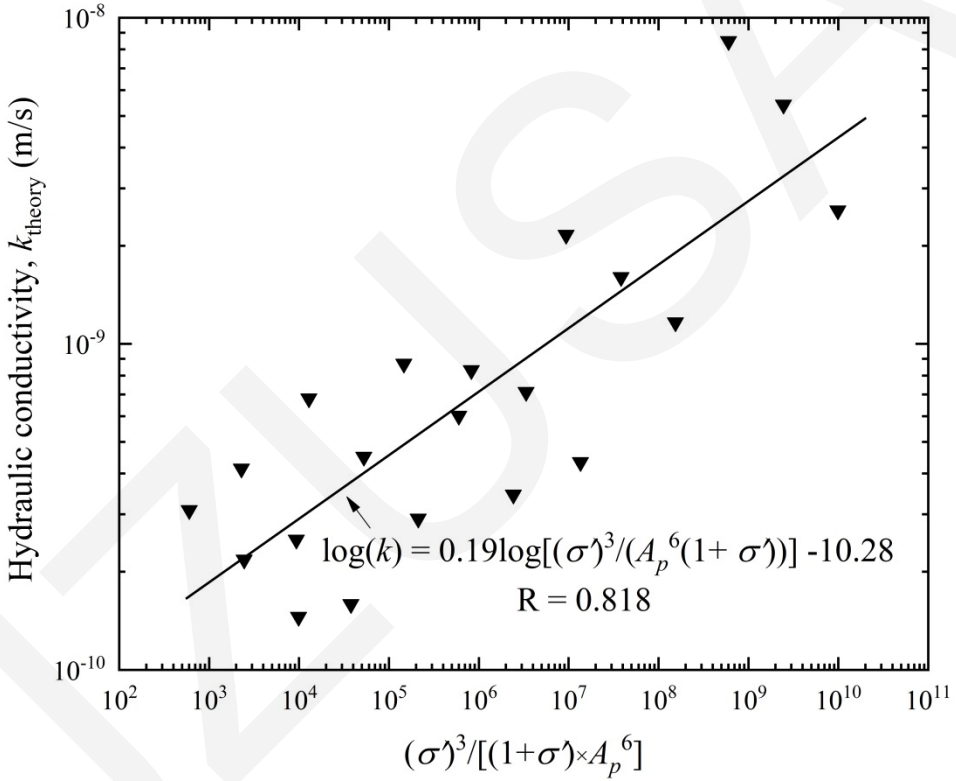


Relationship between the predicted hydraulic conductivity k_p by Method 1 and the hydraulic conductivity k_{theory} calculated based on Terzaghi consolidation theory and the hydraulic conductivity k_f measured by the rigid-wall hydraulic conductivity test

Results

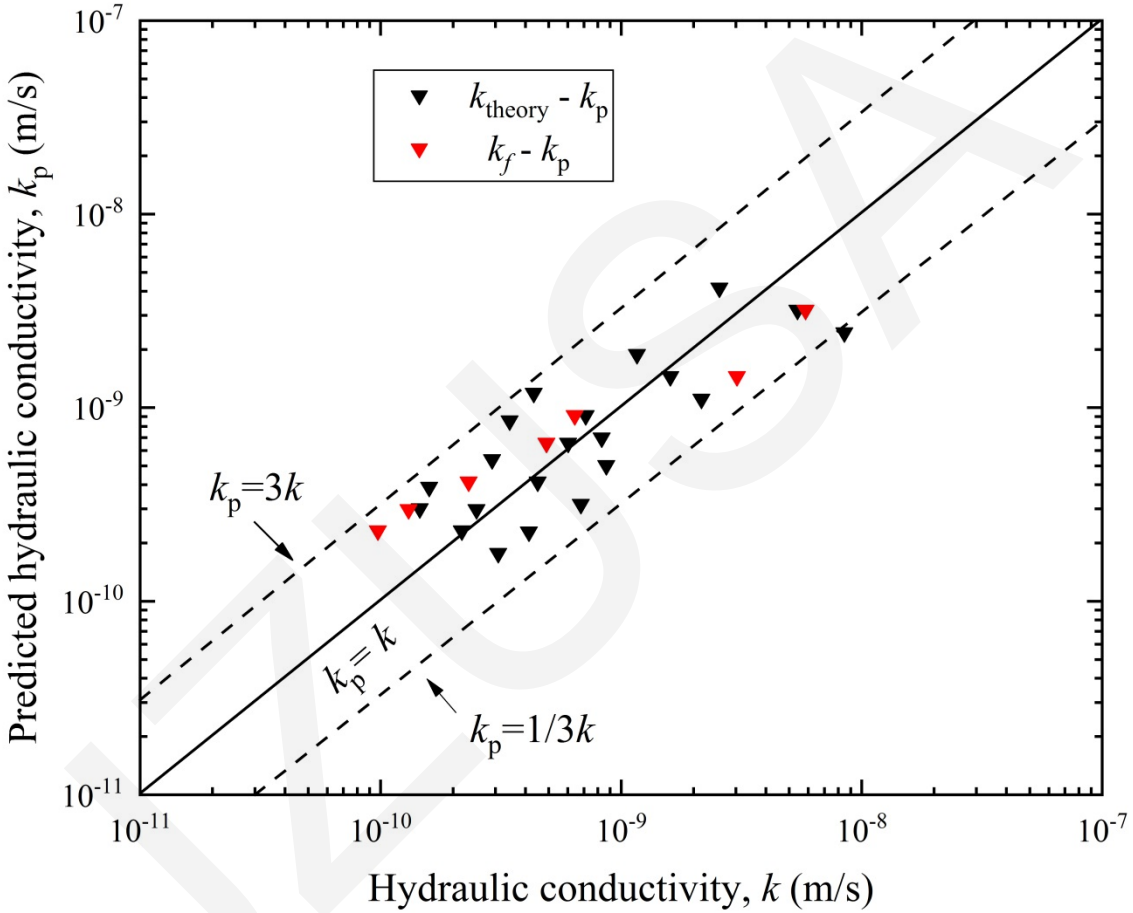
Prediction of hydraulic conductivity (k_p)

Method 2



Relationship between calculated hydraulic conductivity k_{theory} calculated based on Terzaghi consolidation theory and $(\sigma')^3/(A_p^{\ 6}\times(1+\sigma'))$ of the sand-attapulgite backfills at an effective consolidation stress (σ') between 25 and 100 kPa

Results



Relationship between the hydraulic conductivity k_p predicted by Methed 2 and the hydraulic conductivity k_{theory} calculated based on Terzaghi consolidation theory and the hydraulic conductivity k_f measured by the rigid-wall hydraulic conductivity test

Conclusions

- The compression index (C_c) and swell index (C_s) increased with increasing attapulgite content (A_p) in the backfills, and both C_c and C_s had good linear relationships with A_p: $C_c = 0.0062\ A_p + 0.0161$ ($r^2 = 0.9914$), $C_s = 0.0009\ A_p - 0.0058$ ($r^2 = 0.9888$), respectively.

- The hydraulic conductivity (k_{theory}) calculated according to the Terzaghi consolidation theory decreased with increasing attapulgite content in the sand-attapulgite backfill. When the attapulgite content (A_p) $\geq$ 30%, k_{theory} was less than 10^{-9} m/s at the effective consolidation stress (σ') of <100 kPa. The hydraulic conductivity (k_f) measured by the rigid-wall hydraulic conductivity test had the same variation as k_{theory}.

- Two methods based on laboratory data were developed for predicting the hydraulic conductivity of sand-attapulgite backfill. Method 2 was preferred. However, these methods are empirical and whether they can be successfully applied to in-situ fields and other types of backfills needs to be examined in future studies.