

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

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# Research Background

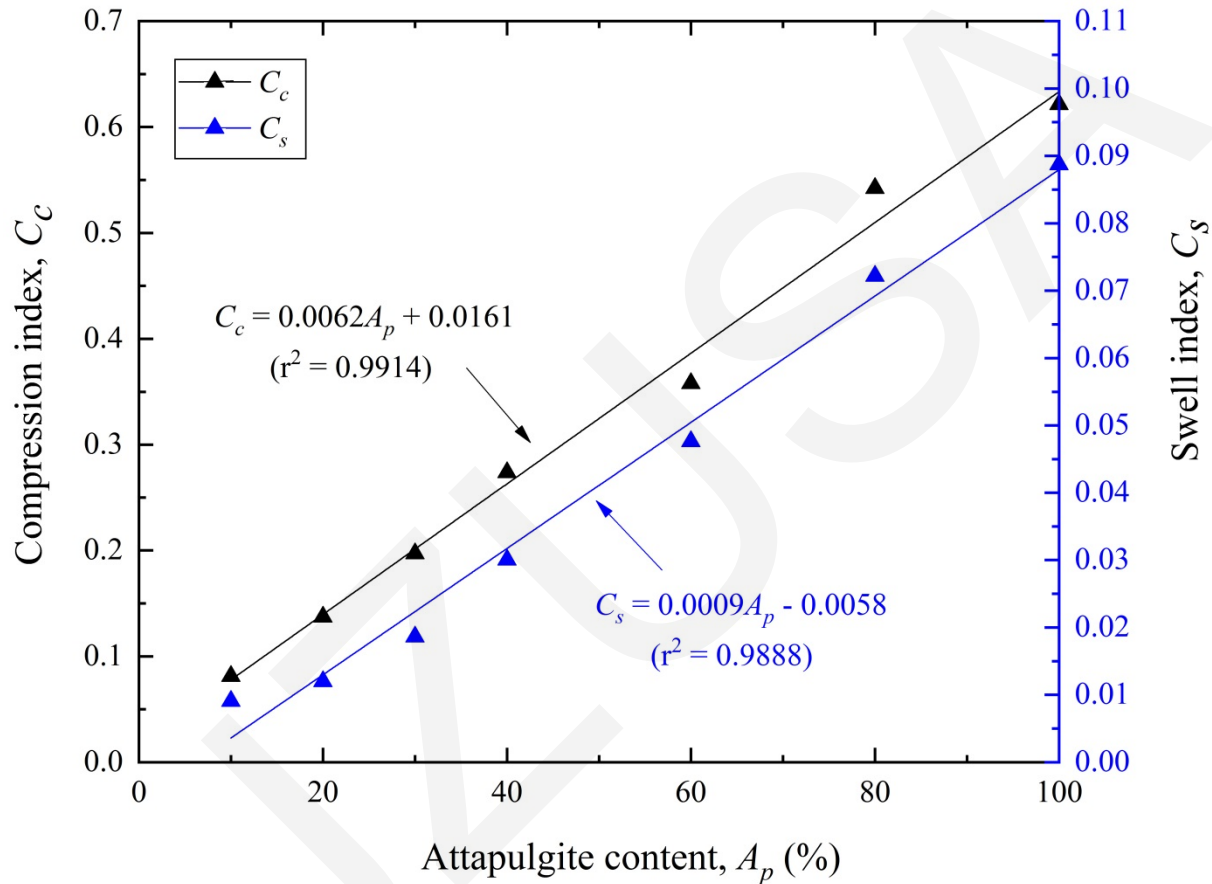
- According to the statistics of the Professional Committee of Urban Domestic Refuse Treatment of China Association of Environmental Protection Industry (2017), the production of municipal solid wastes (MSWs) approached **200 million** tons in 2015, and in China more than **60%** of MSWs are disposed 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).
- Attapulgate 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.

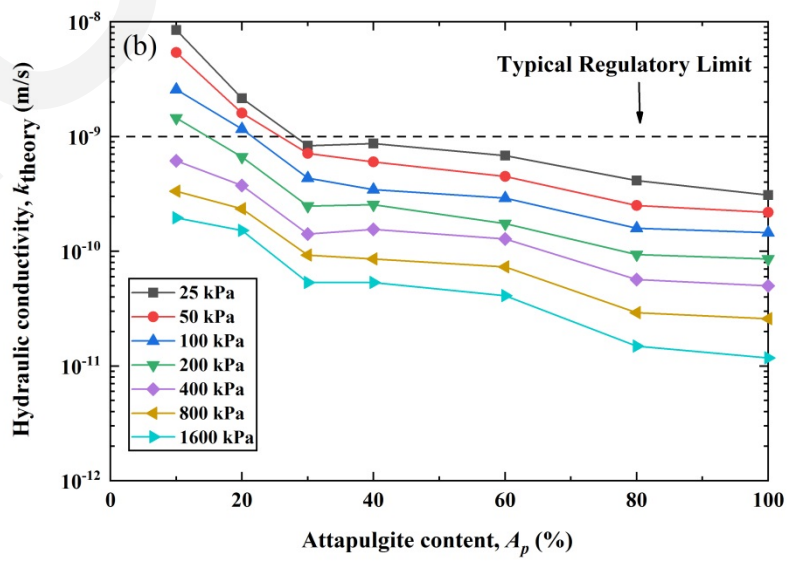
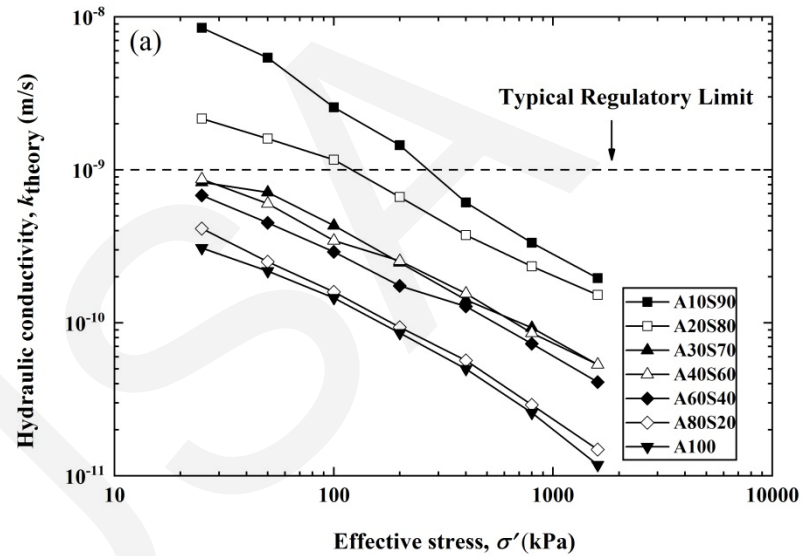
# Results



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

# Results

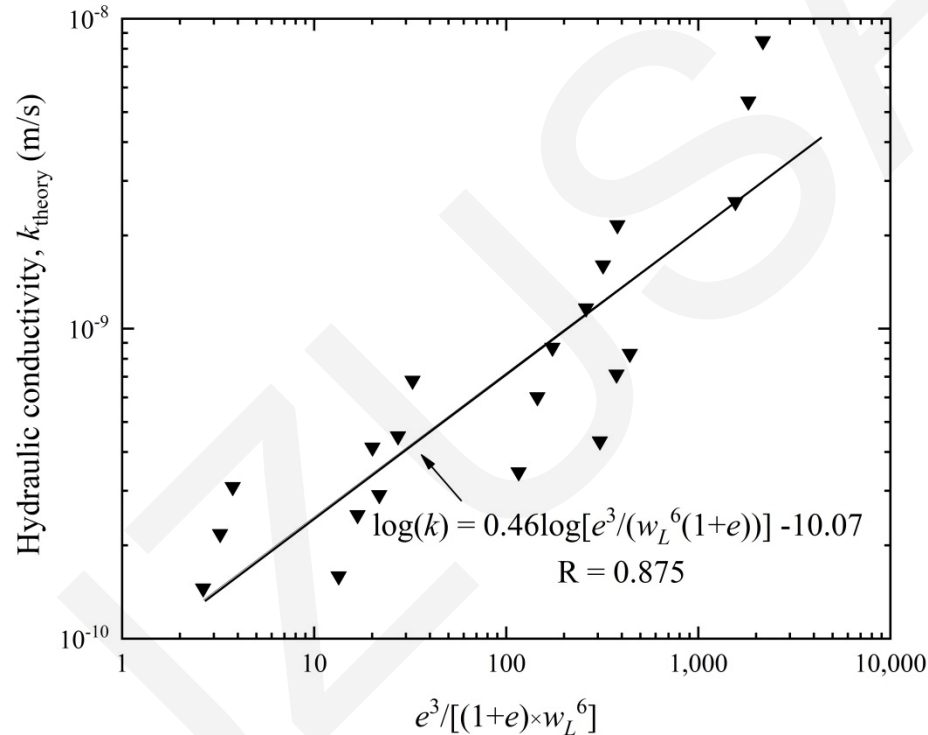
Computed hydraulic conductivity ( $k_{\text{theory}}$ ) changes as a function of (a) effective consolidation stress ( $\sigma'$ ) and (b) attapulgite content, respectively for sand-attapulgite backfills



# Results

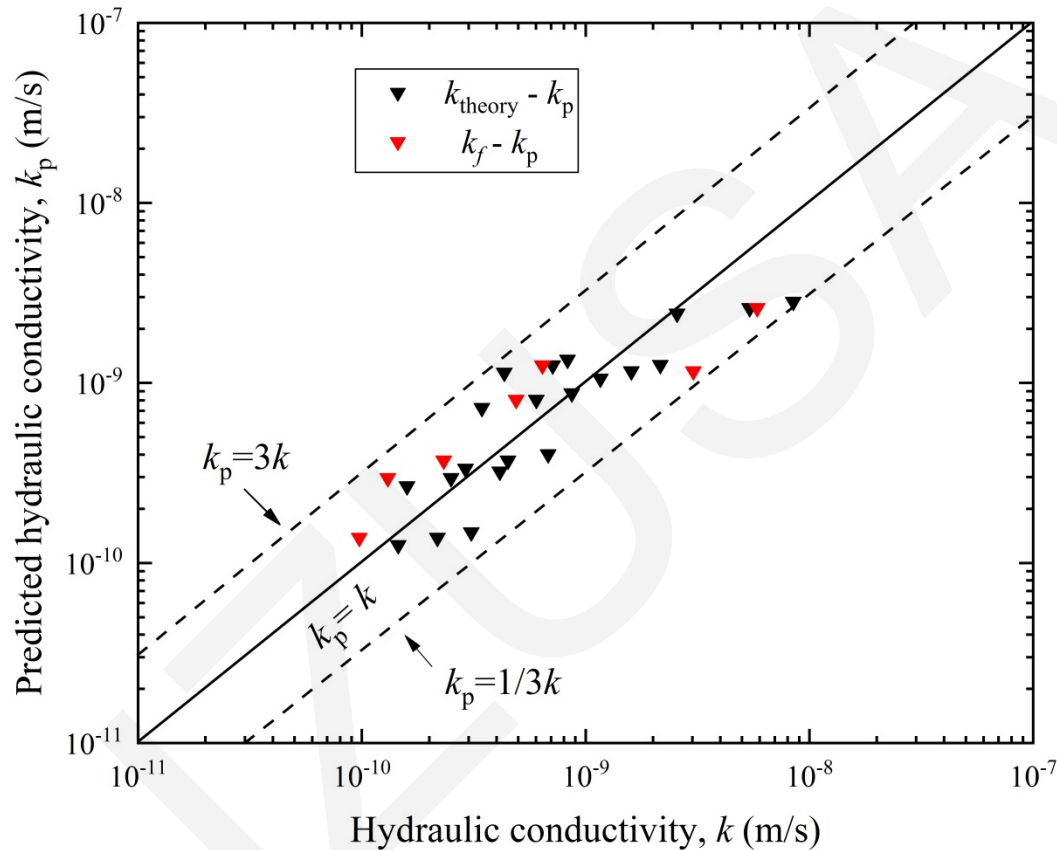
## Prediction of hydraulic conductivity ( $k_p$ )

Method 1



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

# Results

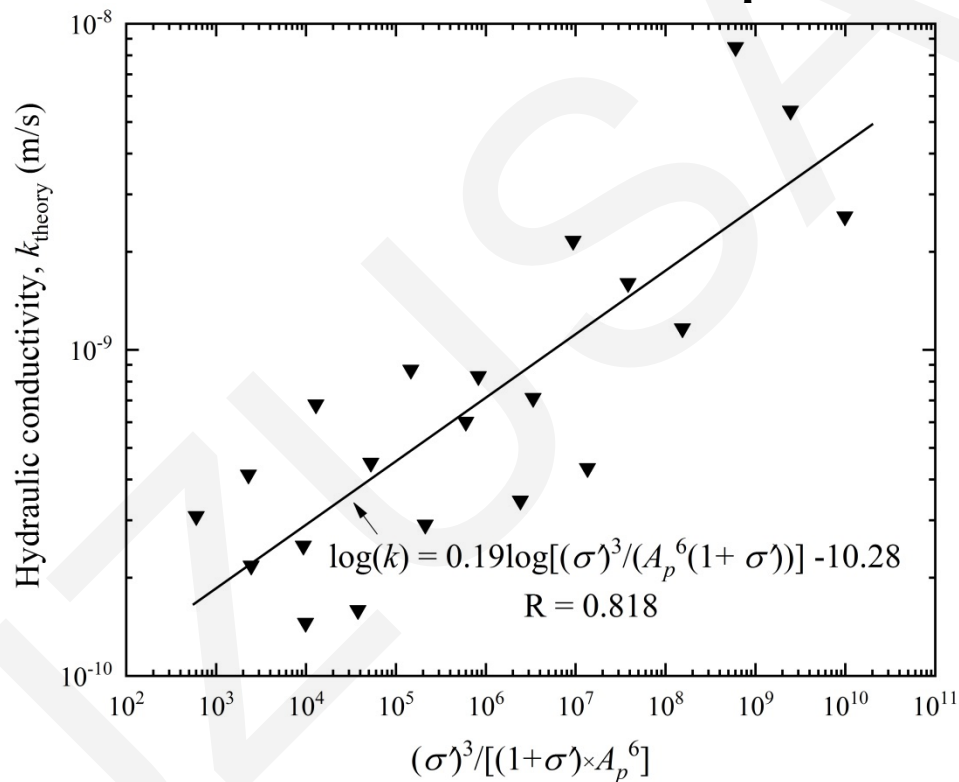


**Relationship between the predicted hydraulic conductivity  $k_p$  by Method 1 and the hydraulic conductivity  $k_{\text{theory}}$  calculated based on Terzaghi consolidation theory and the hydraulic conductivity  $k_f$  measured by the rigid-wall hydraulic conductivity test**

# Results

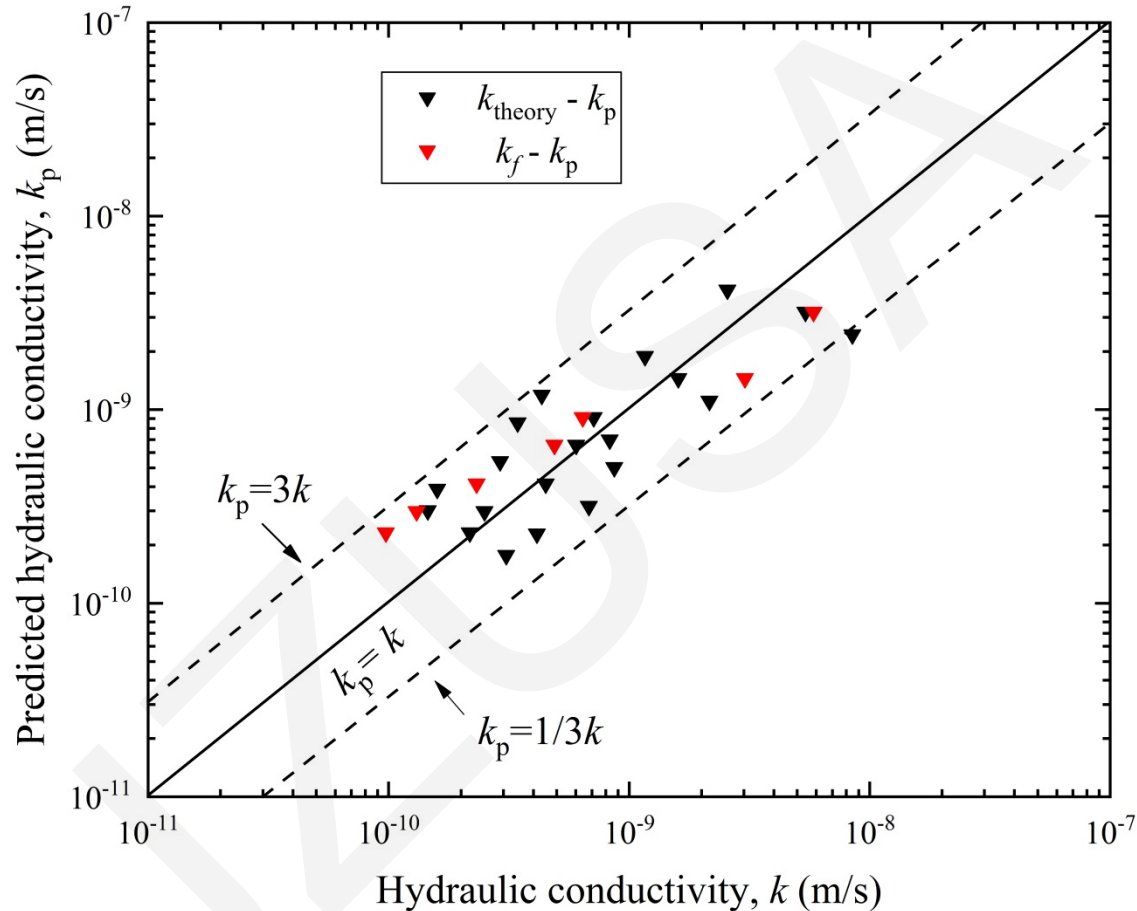
## Prediction of hydraulic conductivity ( $k_p$ )

Method 2



Relationship between calculated hydraulic conductivity  $k_{\text{theory}}$  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 ( $\sigma'$ ) between 25 and 100 kPa

# Results



**Relationship between the hydraulic conductivity  $k_p$  predicted by Method 2 and the hydraulic conductivity  $k_{\text{theory}}$  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 ( $k_{\text{theory}}$ ) calculated according to the Terzaghi consolidation theory decreased with increasing attapulgite content in the sand-attapulgite backfill. When the attapulgite content ( $A_p$ )  $\geq 30\%$ ,  $k_{\text{theory}}$  was less than  $10^{-9}$  m/s at the effective consolidation stress ( $\sigma'$ ) of  $<100$  kPa. The hydraulic conductivity ( $k_f$ ) measured by the rigid-wall hydraulic conductivity test had the same variation as  $k_{\text{theory}}$ .
- 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.