Kaolin Clay as an Analogue for Oil Sands Tailings Reclamation

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Introduction

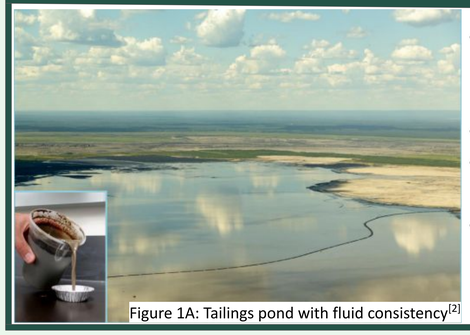


Figure 1A: Tailings pond with fluid consistency[2]

- Oil sands tailings are the slurry waste products of the extraction of oil sands mines. They consist of water, trace amounts of bitumen, chemicals, sand, silt, and clay.[1]
- Tailings ponds are where oil sands tailings are stored.
- They pose a risk to water and wildlife in the area and take up large amount of space.
- The clay component of oil sands tailings poses challenges to the closure and remediation of these tailings ponds.

Figure 1B: Kaolin clay

- Water fills the gaps between the clay particles meaning clay in tailings is weak and soupy.
- To reclaim tailings ponds, clay must be made stronger by reducing its moisture content (ratio of the mass of water to the mass of solids).
- Atterberg Limits are water contents that define the limits of clay behaviour. Below the liquid limit, the clay is weak and fluid. Above the plastic limit, the clay is strong and brittle. In between, the clay is ductile. [3]
- In this project, kaolin clay is used as a comparative substance to oil sand tailings as they behave similarly. We will investigate how kaolin behaves between the liquid and plastic limit, learn more about clay properties, and evaluate kaolin as an analogue for tailings.

Figure 1C: Tailings ponds in northern Alberta[4]

Experimental Methods

Snakes (Plastic Limit):

- Plastic limit is the moisture content at which soil crumbles at a diameter of 3.2mm and can't be re-rolled into a long cylinder (snake).[5]
- Sample is rolled into a ball, then into snakes with a diameter of 3.2 mm. If easily made, snakes are collected, re-rolled into a ball, then back into snakes.
- When snakes can no longer be formed into a ball, pieces meeting the diameter requirement are collected.

Figure 3: Sample snakes at plastic limit[5]

Casagrande Cup (Liquid Limit):

- Clay is added to the cup and a groove is made down the middle.
- As the cup is lifted and dropped repeatedly against the base, clay will fill in the groove[5].
- The number of drops is related to the water content of the sample; if the number of drops is 25, the sample is at the liquid limit.

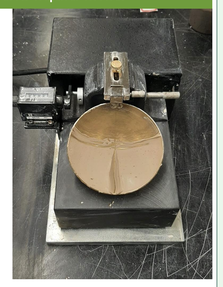
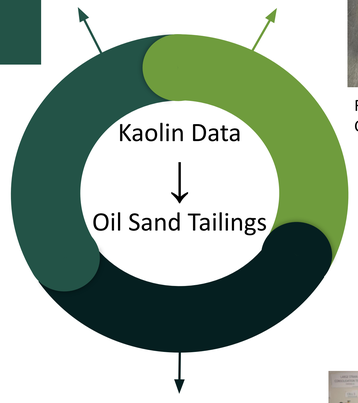


Figure 2: Kaolin sample in Casagrande cup



Fall Cone (Liquid limit and shear strength):

- After penetrating a sample with a cone, formula 1[6] can be used to find shear strength.
- In the formula, shear strength is a function of cone mass, cone angle, and penetration.
- There is a relationship between the remoulded (immediately after mixing) shear strength and moisture content. The moisture content can be expressed relative to the Atterberg limits (liquidity index).
- If depth of penetration is 10mm with a 60 g/60° cone, the sample is at the liquid limit.

1. $S_u = \frac{9.8Km}{p^2}$

Figure 4: Kaolin sample under 60g 60° fall cone

Results

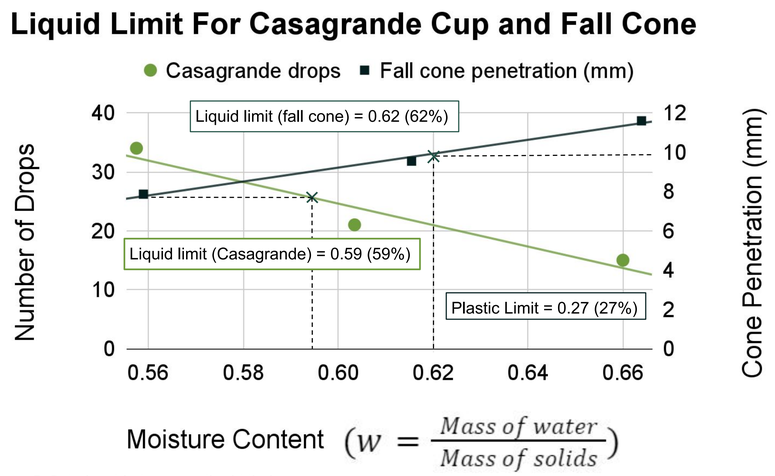


Figure 5: Relationship between liquid limit and moisture content

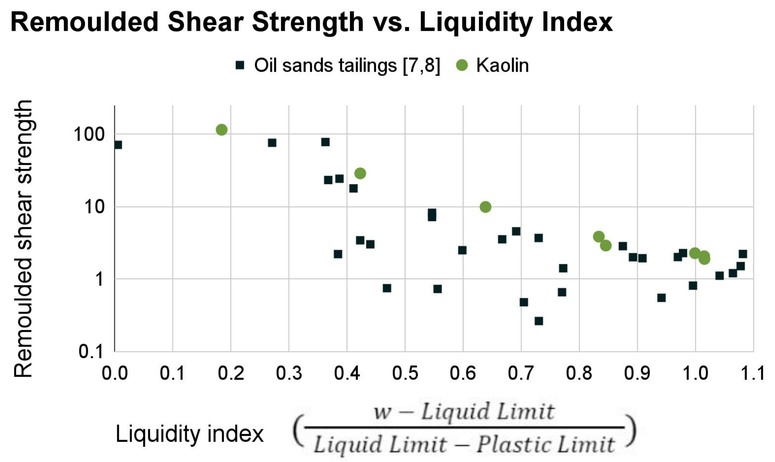


Figure 6: Relationship between shear strength and liquidity index

Conclusions

- Using data in the graphs, were able to learn more about kaolin clay as it becomes stronger.
- We observed the consistency of the clay near its Atterberg Limits and its behaviours and properties at different water contents.

- As shown in Figure 5, the Casagrande cup and fall cone methods are successful in finding the liquid limit of a kaolin sample. There is a 3% absolute difference between the 2 methods.
- As shown in Figure 6, the relationship between the strength and moisture content of kaolin falls within the same range as oil sands tailings. This indicates kaolin data can serve as a reference point for tailings data.

- Kaolin is successful as an analogue because it is homogenous and produces accurate, repeatable results. In comparison, tailings are heterogeneous and sensitive to external factors.

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