50 Years of Successful Learning by Experience, Suncor Tailings Geotechnical

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Thank you
• Production (bpd)
  45,000

• Tailings pond
  1

50 Years
50 Years

- Production (bpd)
  - 45,000
  - 315,000
- Tailings pond
  - 1
  - 11 (2 in reclamation phase)
- 1969 to 2017 photo
Changing Mining Technologies
Early Days: Tar Island Dyke (1968)

- Tar Island Dyke – The Dyke of Firsts
  - First to be built
  - First to discover MFT and beach slopes
  - First to discover that flume to field can come with issues
  - First to experience pressures of no inpit space available
  - First to be increased without overburden and be built with modified upstream construction, hydraulically placed sand
  - First to experience flow or static liquefaction from fast overboarding
  - First pond to be reclaimed
1964: Initial planning had a plan for a 40 ft. (12 m) high overburden dyke
1967: Increased to a 75 ft. (23 m) high overburden dyke
1973: A further height increase required to contain hydraulic fills to 1000 ft. (elev. 305 m)
Today: Final elevation of 1080 ft. (329 m), ultimately 320 ft (98 m)
Planning Interaction

- The push and pull of planning and stable structures
- Natural planning optimism vs geotechnical realism
- Competing needs of
  - Containment
  - Design
  - Availability of footprint and material
- Changing technologies mid stream
- Design 3 times, build once
Tailings

• Starting with Tar Island Dyke
  Modified Upstream Construction

• The requirement was driven by the most common reason for change or ingenuity, necessity
  – Beach slopes not as expected
  – MFT generation
  – No space in pit
  – Sufficient overburden not available for construction

• Precautionary principle
  – Liquefaction assumed however unlikely the triggering event may be

From left to right: Sig Winzer- first Mine Engineer at Great Canadian Oil Sands, F Sullivan- Dredging Expert and, Dean R.M. Hardy- Consultant. These men are credited with creating modified upstream construction as it is still used today.
Construction Evolution: Compaction

- Conventional Compaction
  - rolled at 50 tons/150 psi (4 wheels)
  - Summer only

- Standard Compaction Equipment - The Heavy Hauler
  - Good at dealing with chunky fills (Clearwater) and thicker lifts
  - Several slope failures associated with wet fills and, issues with truck trafficability. **Conclusion** If you can’t drive a truck on the fill then don’t try and build a dyke with it.
Construction Evolution: Winter Construction

• In the late 70’s it was recognized at Suncor that departures to conventional “summer-only” fill placement specifications was necessary to support dyke construction
  • Summer work often delayed by wet weather
  • Heavy truck fleet not fully utilized in winter, and in the summer there is a lack of material availability
  • In situ ground temperatures can be retained within large volumes of fill being transported
• Review of winter constructed waste dump shells indicated reasonable quality fill

Lesson Learned: In all seasons construction trafficking drier fills with heavy haulers resulted in a superior density product than could be achieved with conventional compaction procedures.
Dealing with “Blocky fills” especially for Clearwater (Kc) clay-shales for overburden fill placement is a challenge.

**Construction Evolution: Clearwater**

- Blocks of Kc fill
- Area with no truck traffic. Open structure highly susceptible to dispersive piping and internal erosion.
- K1 Zone in WCD – tight dense structure
- Kc fills are highly dispersive in contact with fresh water. Pond waters appear to suppress dispersion to some extent.
Foundations: Low Residual Strengths

- Clearwater Formation (Kc), as well as certain clay rich facies in the McMurray Formation (Km), contains highly sheared zones with very low residual strengths.
- These shear zones have been induced by glacial drag as well as structural downwarping of the basal limestone formation.
- Not until Skempton’s Rankine Lecture in 1964 did people begin to understand the impacts of pre-sheared zones on dyke and pitwall stability.
Foundations: Low Residual Strengths

- Mining especially along pit walls sometimes provides interesting opportunities to view shear localization usually only deduced by slope inclinometers.
- Problems with these units are managed by either very flat slopes or excavation and backfilling of shear keys, or both, along with the Observational Method.
- Slopes can be as flat as 17H: 1V to 20H: 1V in principle
- Experience with the movement and the use of the observational approach, the slopes used in design tend to be somewhat steeper with contingency planned.
Foundations: Low Residual Strengths

**Learnings:**
- Start with relatively steeper slope as indicated by case records.
- Monitor structure and in the event of movements, pre-planned contingency measures are executed.
- This approach requires that toe areas reserved for stabilization berms are clearly identified.
- The other option available is stepping out over upstream beaches into pond, however this reduces available tailings volumes.
Reclamation & Closure

- As Suncor has been operation for 50 years, closure is at the forefront of our minds
- The first tailings area in Alberta’s oil sands region to be reclaimed is Pond 1
- Accomplished by transferring MFT for treatment elsewhere and simultaneously infilling with coarse sand tailings.

- Suncor’s Pond 5 surface was made trafficable by installing a semi-anchored floating engineered cover that includes, geogrid and geofabric covered with coke
- Some MFT with soft tailings was left in place and consolidation is being induced with wick drains
Sand Dumps – End in Mind

- Suncor changed the tailings approach and designed directly with the end in mind.
- The Sand Dump will be a readily reclaimable, decommissionable tailings sand structure.
- The fluid pond is kept small and TFT is immediately removed, while MFT is generated and treated elsewhere.
- The final closure scenario is simplified to removal of the relatively small volume of fluids and then reclamation.
What have we learned in 50 years?

- While challenges remain, significant improvements and advancements in geotechnical engineering are evident
  - Still to come, reclamation and de-licensing!!

- MFT was a surprise 50 years ago and while not an unknown, not fully solved either

- Ultimately, the success of a geotechnical structure relies on the operational discipline and integration of
  - Planning
  - Technology
  - Operations
  - Geotechnical Engineering

- With guidance and review from
  - Geotechnical Review Boards
  - Regulatory Bodies

Success of a tailings facility is not an individual sport