Effects of decant pond seepage in tailing dams

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Introduction

One risk that could occur in tailings dam stability is the seepage generated by supernatant pond, where in some projects is not considered. Its propose using computational software to seepage modeling, using different configurations dams, building and operating conditions. Effects of seepage in failure mechanisms are evaluated from experiences observed of several Chilean tailings dams.
Seepage estimation methods

• For such problems there is a wide range of commercial programs: SEEP/W, MODFLOW, HYDRUS 2D, SVFlux, etc.
• In this work SEEP/W software was used, with 2D models, which allow to model tailings dams profiles using different conditions.
• SEEP/W allows a simple and quick study, ideal for mining industry.
Input parameters

• Geometry analyzed: three sand dam heights, corresponding to 15, 40 and 70 m. The slopes chosen were 1:2 (V:H) and 1:3 (V:H) for the upstream and downstream slope respectively.

• Commonly range of hydraulics conductivity:

<table>
<thead>
<tr>
<th>Material</th>
<th>Minimum value [m/s]</th>
<th>Maximum value [m/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation soil</td>
<td>$1.0 \times 10^{-6}$</td>
<td>$1.0 \times 10^{-4}$</td>
</tr>
<tr>
<td>Tailing sand</td>
<td>$1.0 \times 10^{-5}$</td>
<td>$1.0 \times 10^{-4}$</td>
</tr>
<tr>
<td>Fine fraction</td>
<td>$1.0 \times 10^{-7}$</td>
<td>$1.0 \times 10^{-5}$</td>
</tr>
</tbody>
</table>


The maximum value was used for modeling.
Considerations

• Steady state condition and homogeneous and isotropic materials were assumed.
• Base sealing (Q=0, Flux Type), corresponds to a layer of bedrock with low permeability (depth 20 m).
Considerations

• Downstream slope an dam is sealing (Q=0, Flux Type). Represents that no flow on slope surface.

• Seal of starter dam (geo-membrane) (Q=0, Flux Type).

• Decant pond is represented as a constant head value (H)

• Drainage System. Basal drainage clean gravel (k= 1,0 x E-1 m/s)
Results. Distance of supernatant pond

Distance: 50 m

Flux v/s distance of supernatant pond

Flux [L/s]

Distance of supernatant pond [m]
Results. Drainage operative and non-operative.
Results. Length of the liner

Sealing foundation soil it is considered (300 m corresponds to a fully sealed deposit)
Effects of seepage in the stability of dams

- Results from SEEP/W analysis were used.
- In order to perform the dam's slope stability, the Limit Equilibrium Method (MEL) is used by SLOPE/W software.
- It was analyzed a dam of 40 m, considering an operating drain and one clogged by fine (non-operating).
Effects of seepage in the stability of dams.

- Drainage operative and non-operative (clogging).

<table>
<thead>
<tr>
<th>Material</th>
<th>$\gamma$ [kN/m$^3$]</th>
<th>$\Phi$ [$^\circ$]</th>
<th>$C$ [kPa]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation soil</td>
<td>20</td>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td>Tailing sand</td>
<td>17</td>
<td>38</td>
<td>0</td>
</tr>
<tr>
<td>Fine fraction</td>
<td>15</td>
<td>25</td>
<td>0</td>
</tr>
</tbody>
</table>

Elaborated by authors
Effects of seepage in the stability of dams.

• Other failure mechanism.
  • Increasing the degree of saturation and the presence of flows in the body wall, can activate other failure mechanisms, such as liquefaction and internal erosion (Piping).
  • Liquefaction analysis is requested by regulations (DS N°248), however an internal erosion analysis is not included.
Comments

Input
- Generation of decant pond.
- Sealed of deposit.
- Type of drain.

Seepage study
- Velocity vectors.
- Water table.

Design
- Stability.
- Internal erosion.
- Liquefaction.

Construction and operation
- Estate of drainage.
- Ubicacion of decant pond.
Final conclusions

• Results allow us to recognize and quantify the importance of certain factors such as distance from the decant pond, drainage, sealing system, in the stability of a tailings dam.

• A physical stability study of a tailings dam need incorporate a seepage analysis. This aspect could be included in the DS No. 248.
Final conclusions

• It is necessary ensure a correct implementation of the drainage system in construction and extensions stages.

• A complete control of the decant pond focused on establishing a minimum distance, and water table control on the dam.
Thank you for your attention