Rock Slope Wedge Failure

Typical wedge failure involving sliding on two persistent joints with line of intersection of joints daylighting at toe of rock face, and an upper plane that formed a tension crack.

Problem statement:
Computer aided analysis of wedge stability by means of the computer code SWEDGE (Rocsience).

Figure. 1: Dimensions and surfaces defining size and shape of wedge.

Density $\rho = 2700 \text{ kg/m}^3$

Table 1: Failure planes

<table>
<thead>
<tr>
<th>Plane</th>
<th>Dip direction $[^\circ]$</th>
<th>Dip $[^\circ]$</th>
<th>$\varphi\ [^\circ]$</th>
<th>$c \text{ [kN/m}^2]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Joint set 1</td>
<td>65-95</td>
<td>50-80</td>
<td>38</td>
<td>30</td>
</tr>
<tr>
<td>2 – Joint set 2</td>
<td>340-355</td>
<td>40-70</td>
<td>38</td>
<td>2</td>
</tr>
<tr>
<td>5 – Tension crack</td>
<td>No tension crack is considered in this example</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Free surfaces

<table>
<thead>
<tr>
<th>Plane</th>
<th>Dip direction $[^\circ]$</th>
<th>Dip $[^\circ]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 – Upper ground surface</td>
<td>356</td>
<td>0</td>
</tr>
<tr>
<td>4 – Slope face</td>
<td>356</td>
<td>65</td>
</tr>
</tbody>
</table>
Figure 2: Failure mechanism – SWEDGE

Figure 3: Limit equilibrium solution for wedge failure under dry conditions and with frictional strength only (after Hudson & Harrison 1977)

\[ SF = \frac{(R_A + R_B) \tan \phi}{W \sin \psi_i} \]

and \[ R_A + R_B = \frac{W \cos \psi_i \sin \beta}{\sin(0.5 \delta)} \]

Where: 
- \( SF \) = safety factor 
- \( \phi \) = friction angle 
- \( \psi_i \) = dip of the line of intersection 
- \( W \) = weight of block 
- \( \beta, \delta \) = wedge geometry factors
Questions:

Analyze the following stability conditions for a slope height of $H_1=40$ m and $H_1=80$ m.

1. Calculate the probability of failure and the mean factor of safety for the joint set given in table 1 and 2.
2. Determine the factor of safety and the probability of failure if the cohesion were to be reduced to zero (friction-only calculation)
3. Verify the results of (2) using the solution after Hudson & Harrison (figure 3)
4. Presume that 50% of joints are filled with water for case (1) and (2)

It’s recommended to use the probabilistic feature of SWEDGE to solve the problem!

The program SWEDGE is available in the IT-room for civil engineering students:

Ort: Stiege 7 direkt unter HS 8
Mo-Do 10 - 17h
Fr 10 - 16h

References: