INFINITE SLOPE ANALYSIS

February, 1972

7.41-6, SEM 3/72
INFINITE SLOPE
ANALYSIS
<table>
<thead>
<tr>
<th>TABLE OF CONTENTS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>2</td>
</tr>
<tr>
<td>Derivation of Equation</td>
<td>3</td>
</tr>
<tr>
<td>Typical Section (Fig. 1)</td>
<td>5</td>
</tr>
<tr>
<td>Force Diagram (Fig. 2)</td>
<td>5</td>
</tr>
<tr>
<td>Infinite Slope Curves</td>
<td>6</td>
</tr>
<tr>
<td>Variance of SF with Total Unit Weight</td>
<td>20</td>
</tr>
<tr>
<td>Appendix A The Computer Program</td>
<td>21</td>
</tr>
</tbody>
</table>
The infinite slope analysis for cut slopes is designed to allow the engineer to approximate the factor of safety existing in the field knowing the angle of internal friction of the soil, the existing slope angle, the depth to the actual or potential failure plane and the depth to the water table.

The $H/W$ ratio is the ratio of the depth to water divided by the depth to the actual or potential failure plane (Fig. 1) and ranges from 0 for the water table at the original ground surface to 1.0 for the water table existing at the failure plane.

This analysis assumes that the original ground surface and the water table are parallel and that the ratio of depth to length of the failure is very small, therefore eliminating the active and passive wedges.

The analysis and resulting stability curves was based on a total unit weight of 125 pcf. Stability curves are also presented in Fig. 3 showing the variance of safety factor with changes in total unit weight.
DERIVATION OF THE EQUATION

From Fig. 2

\[ FS = \text{Resisting Overturning} \]

1) OT = Weight and seepage

2) \[ F = W \sin(a) = (bh_1 G_T + bh_2 G_b) \sin(a) = b \sin(a) (h_1 G_T + h_2 G_T - h_2 G_w) \]

3) Seepage = \[ i G_w bh_2 = \sin(a) bh_2 G_w \]

\[ OT = b \sin(a) h_2 G_w + b \sin(a) (h_1 G_T + h_2 G_T - h_2 G_w) \]
\[ = b \sin(a) (h_2 G_w + h_1 G_T + h_2 G_T - h_2 G_w) \]
\[ = b \sin(a) (h_1 G_T + h_2 G_T) \]

4) Resisting Forces = \[ N \tan \phi \]

\[ N = W \cos(a) = b \cos(a) (h_1 G_T + h_2 G_T - h_2 G_w) \]

\[ R = \tan \phi b \cos(a) (h_1 G_T + h_2 G_T - h_2 G_w) \]

5) SF = \[ \tan \phi b \cos(a) (h_1 G_T + h_2 G_T - h_2 G_w) \]

\[ = \tan \phi \frac{b \sin(a) (h_1 G_T + h_2 G_T)}{\tan(a) (h_1 G_T + h_2 G_T)} \]

\[ = \tan \phi \left( \frac{h_1 G_T + h_2 G_T - h_2 G_w}{h_1 G_T + h_2 G_T} \right) \]

\[ = \tan \phi \left( \frac{1}{\tan(a)} \left( \frac{h_1 G_T + h_2 G_T - h_2 G_w}{h_1 G_T + h_2 G_T} \right) \right) \]

\[ = \tan \phi \left( \frac{1 - \frac{h_2 G_w}{G_T Z}}{\tan(a)} \right) \]

\[ = \tan \phi \left( \frac{1 - \frac{(Z - h_1) G_w}{G_T Z}}{\tan(a)} \right) \]
Definition of Terms

$G_T$ = total unit wt.

$G_w$ = unit wt. of water

$G_b$ = bouyant unit weight

$Z = h_1 + h_2$

$a = slope\ angle$

For this analysis $G_T = 125$ was used.

\[
\frac{\tan \phi}{\tan(a)} = \frac{1}{1 + \frac{G_w}{G_T Z} \left( \frac{h_1 G_w - G_w}{G_T Z} \right)}
\]
CROSS-SECTION
FIG. 1

FORCE DIAGRAM
FIG. 2

$\delta_T = 125 \text{ PCF}$

$\delta_W = 62.4 \text{ PCF}$

$h_1 + h_2 = Z$
\[ \theta = 20^\circ \]

SLOPE ANGLE AND HYDRAULIC GRADIENT

SAFETY FACTOR

\[ \frac{H}{L} \]

30  26  22  18  14
\[ \phi = 22^\circ \]

SAFETY FACTOR

SLOPE ANGLE AND HYDRAULIC GRADIENT
\[ \phi = 24^\circ \]

SLOPE ANGLE AND HYDRAULIC GRADIENT
$\theta = 26^\circ$

$H \sqrt{Z} = \text{Slope Angle and Hydraulic Gradient}$

Safety Factor

30 26 22 18 14
SLOPE ANGLE AND HYDRAULIC GRADIENT

φ = 30°
SLOPE ANGLE AND HYDRAULIC GRADIENT
SLOPE ANGLE AND HYDRAULIC GRADIENT
SLOPE ANGLE AND HYDRAULIC GRADIENT

$\theta = 36^\circ$

$H_1/Z = 1.0, 0.8, 0.6, 0.4, 0.2, 0.0$
$\theta = 40^\circ$

Slope Angle and Hydraulic Gradient

Safety Factor vs. Slope Angle and Hydraulic Gradient

$\frac{H}{Z^2}$

Slope Angle and Hydraulic Gradient
$\phi = 44^\circ$. 

SLOPE ANGLE AND HYDRAULIC GRADIENT

SAFETY FACTOR

$\frac{h}{Z} = 1$
TOTAL UNIT WEIGHT VS SAFETY FACTOR FOR 1:3 SLOPE

LEGEND

$H_1/Z = \text{RATIO DEPTH OF WATER TABLE TO DEPTH OF OVERBURDEN.}$

- $H_1/Z = 0$
- $H_1/Z = 0.5$
- $H_1/Z = 1.0$

FIG. 3
THE COMPUTER PROGRAM

PRINT TAB (25) "INFINITE SLOPE ANALYSIS"
PRINT
FOR A=20 TO 46 STEP 2
PRINT A
PRINT "1:3", "1:3.5", "1:4", "1:4.5", "1:5"
PRINT
FOR B=0 TO 1 STEP .2
FOR C=3 TO 5 STEP .5
G1=62.4
G2=125
F=TAN(A*3.141/180)*(1-G1/G2+G1*B/G2)*C
PRINT F,
NEXT C
NEXT B
PRINT
PRINT
PRINT
PRINT TAB (25) "DEFINITION OF TERMS"
PRINT
PRINT "A=PHI", "B=H1/Z", "C=1/SLOPE", "G1=WATER", "G2=TOTAL WT."