Fayoum University

Faculty of Engineering

Department of Civil Engineering

CE 402: Part D

Slope Stability Analysis

Lecture No. (18)

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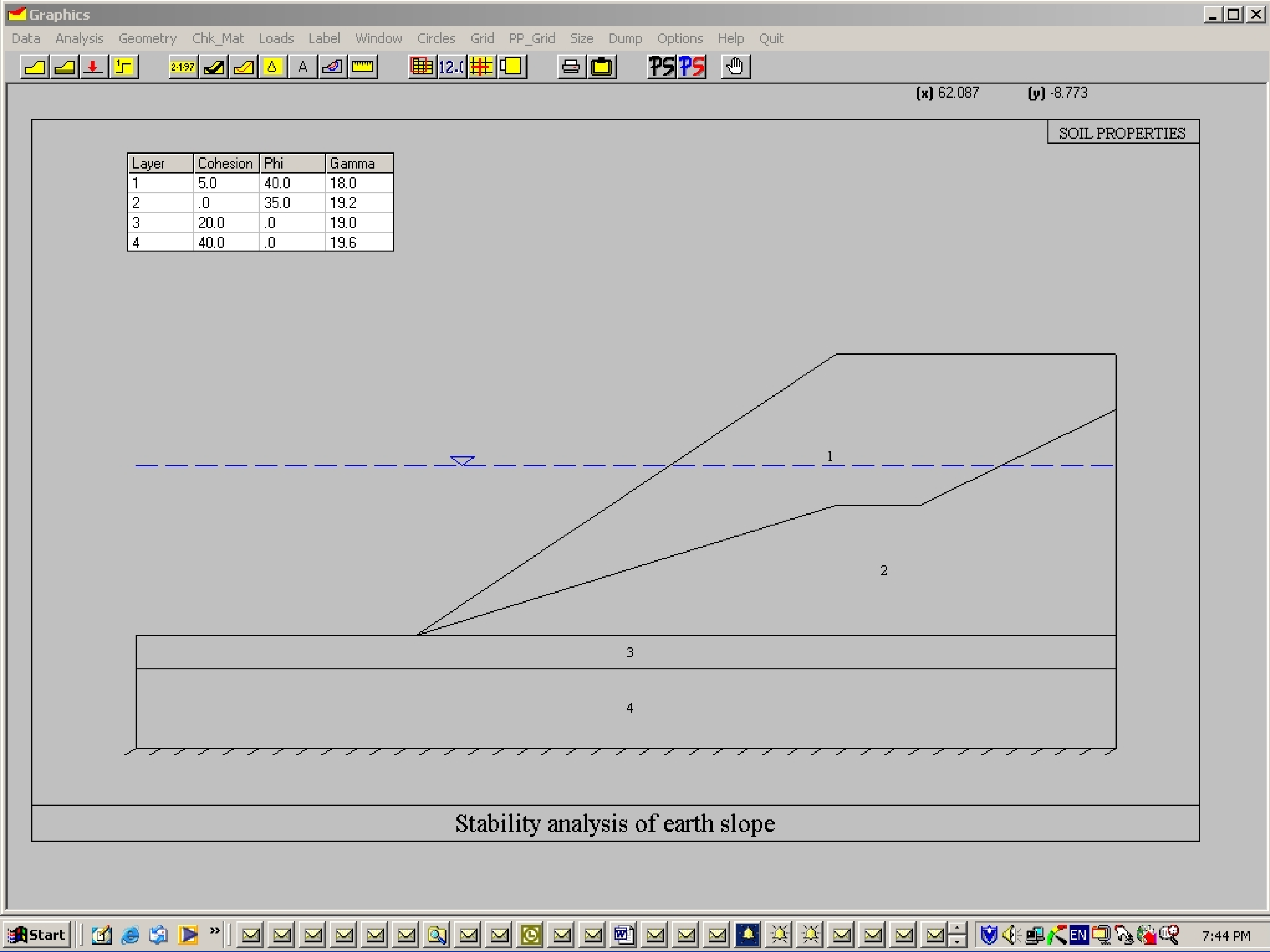
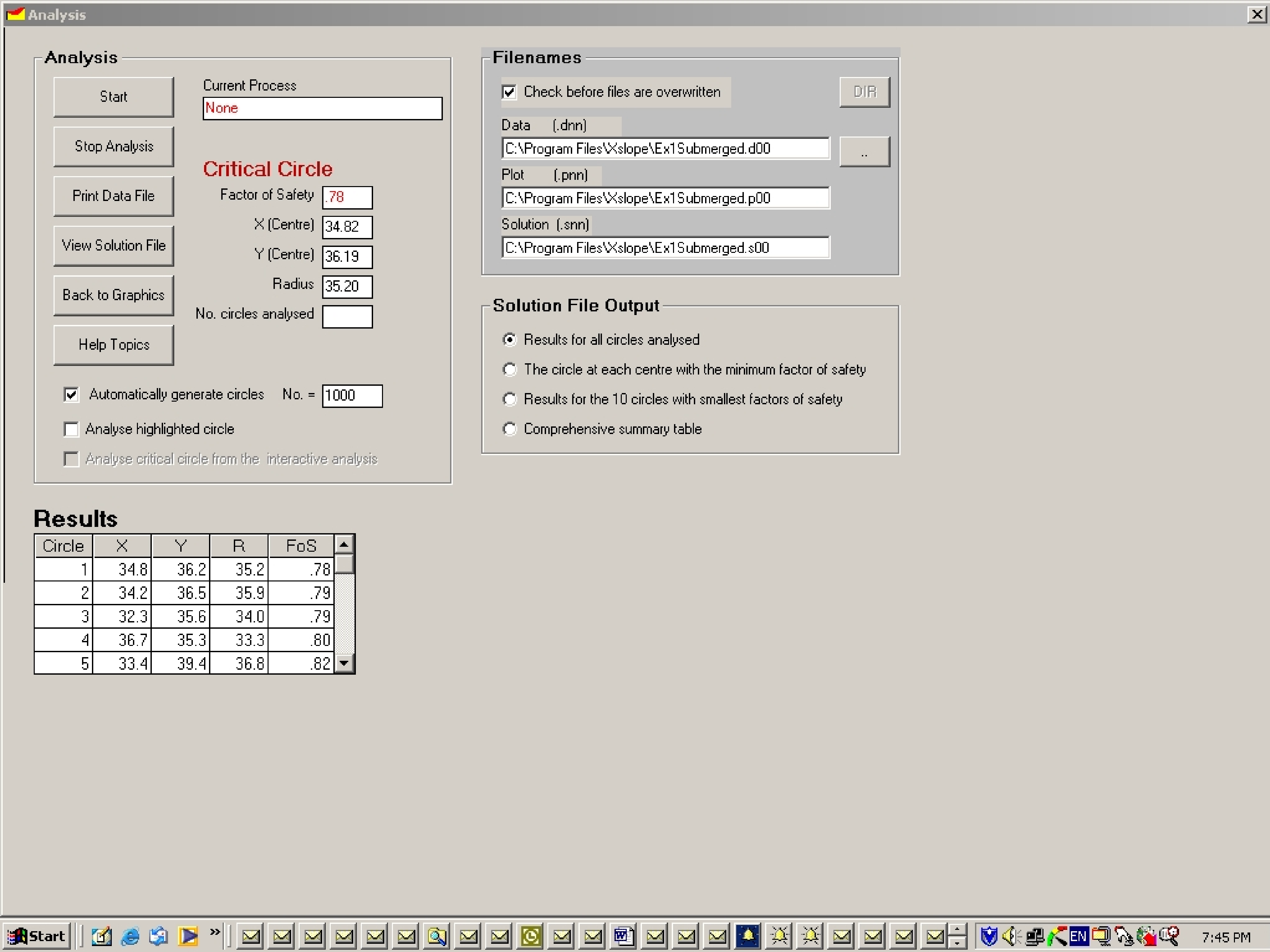
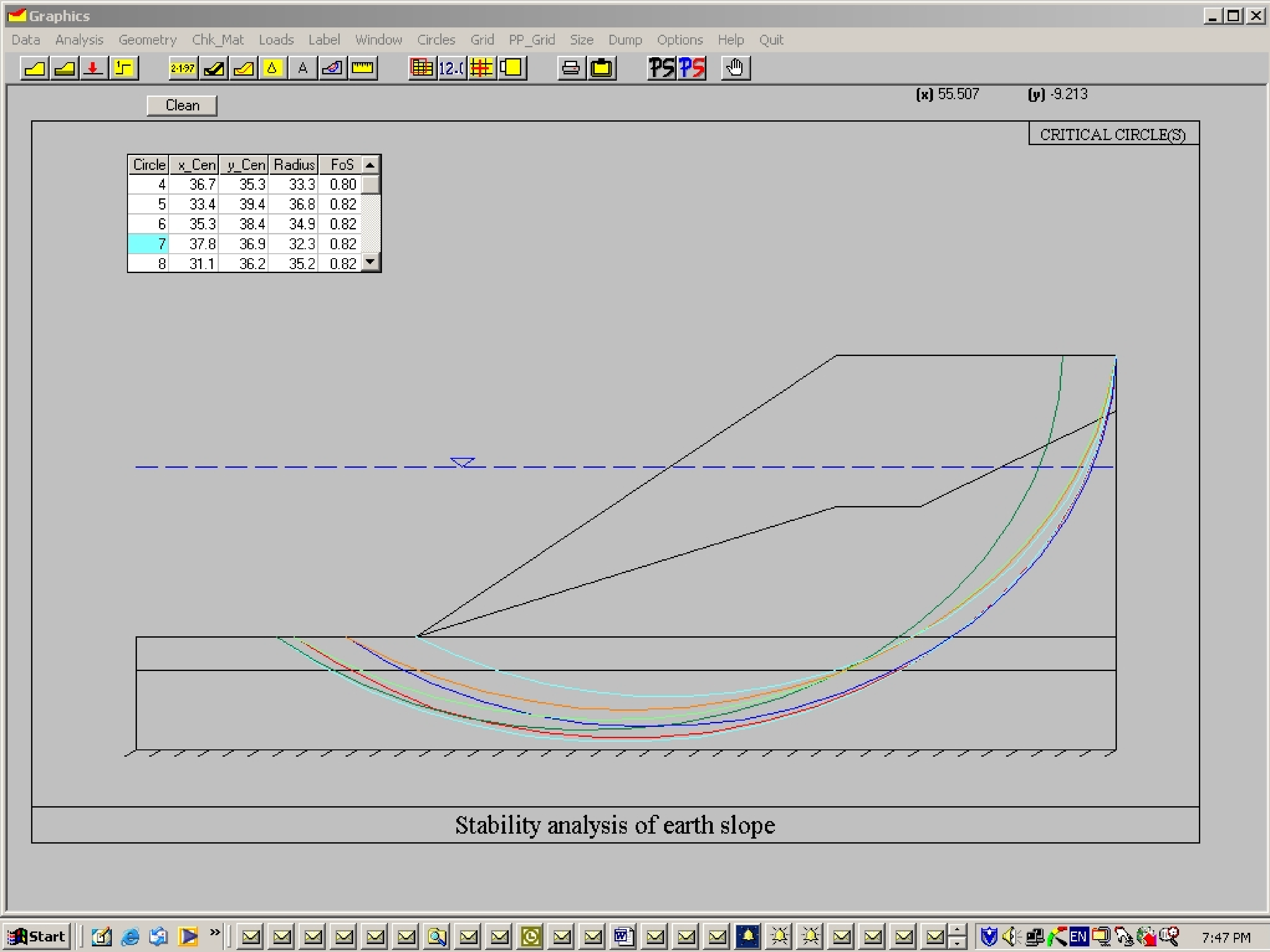
Simplified Bishop Method

- Requires iteration
  - Assume initial F, then solve for F
  - When trial F and determined F are equal, it's a solution
- Spreadsheet for simple slopes
- XSLOPE and GALENA otherwise
  - 1000 trial surfaces in 1 minute



Layer	Cohesion	Phi	Gamma
1	5.0	40.0	18.0
2	.0	35.0	19.2
3	20.0	.0	19.0
4	40.0	.0	19.6


Analysis
Analysis
Start
Stop Analysis
Print Data File
View Solution File
Back to Graphics
Help Topics
Current Process
None
Critical Circle
Factor of Safety .78
X (Centre) 34.82
Y (Centre) 36.19
Radius 35.20
No. circles analysed
Automatically generate circles No. = 1000
Analyse highlighted circle
Analyse critical circle from the interactive analysis
Filenames
Check before files are overwritten
DIR
Data (.dnn)
C:\Program Files\Xslope\Ex1Submerged.d00
Plot (.pnn)
C:\Program Files\Xslope\Ex1Submerged.p00
Solution (.snn)
C:\Program Files\Xslope\Ex1Submerged.s00
Solution File Output
Results for all circles analysed
The circle at each centre with the minimum factor of safety
Results for the 10 circles with smallest factors of safety
Comprehensive summary table
Results
Circle X Y R FoS
1 34.8 36.2 35.2 .78
2 34.2 36.5 35.9 .79
3 32.3 35.6 34.0 .79
4 36.7 35.3 33.3 .80
5 33.4 39.4 36.8 .82
Start
EN
7:45 PM



Circle	x_Cen	y_Cen	Radius	FoS
4	36.7	35.3	33.3	0.80
5	33.4	39.4	36.8	0.82
6	35.3	38.4	34.9	0.82
7	37.8	36.9	32.3	0.82
8	31.1	36.2	35.2	0.82

Other Methods

- More exact solutions exist, but little improvement on accuracy

- Choosing the soil shear strength factors and soil layers are **far more important**

Numerical Approach to Slopes

Finite Element Analysis(FEA)

Finite Difference

Benefits:

- Progressive failure
  - shear strength *mobilization* not uniform along sliding surface
- Distortions as well as safe slope angle

But more effort

Tension Cracks

In cohesive soil, tension cracks are usually present at the crest. The depth of such cracks may be computed from the equation

The effective length of any trial arc of failure is the difference between the total length of arc minus the depth of crack

Tension Cracks

This same crack can fill up with water and so a hydrostatic force (acting horizontally) can be introduced which adds to the potential instability;

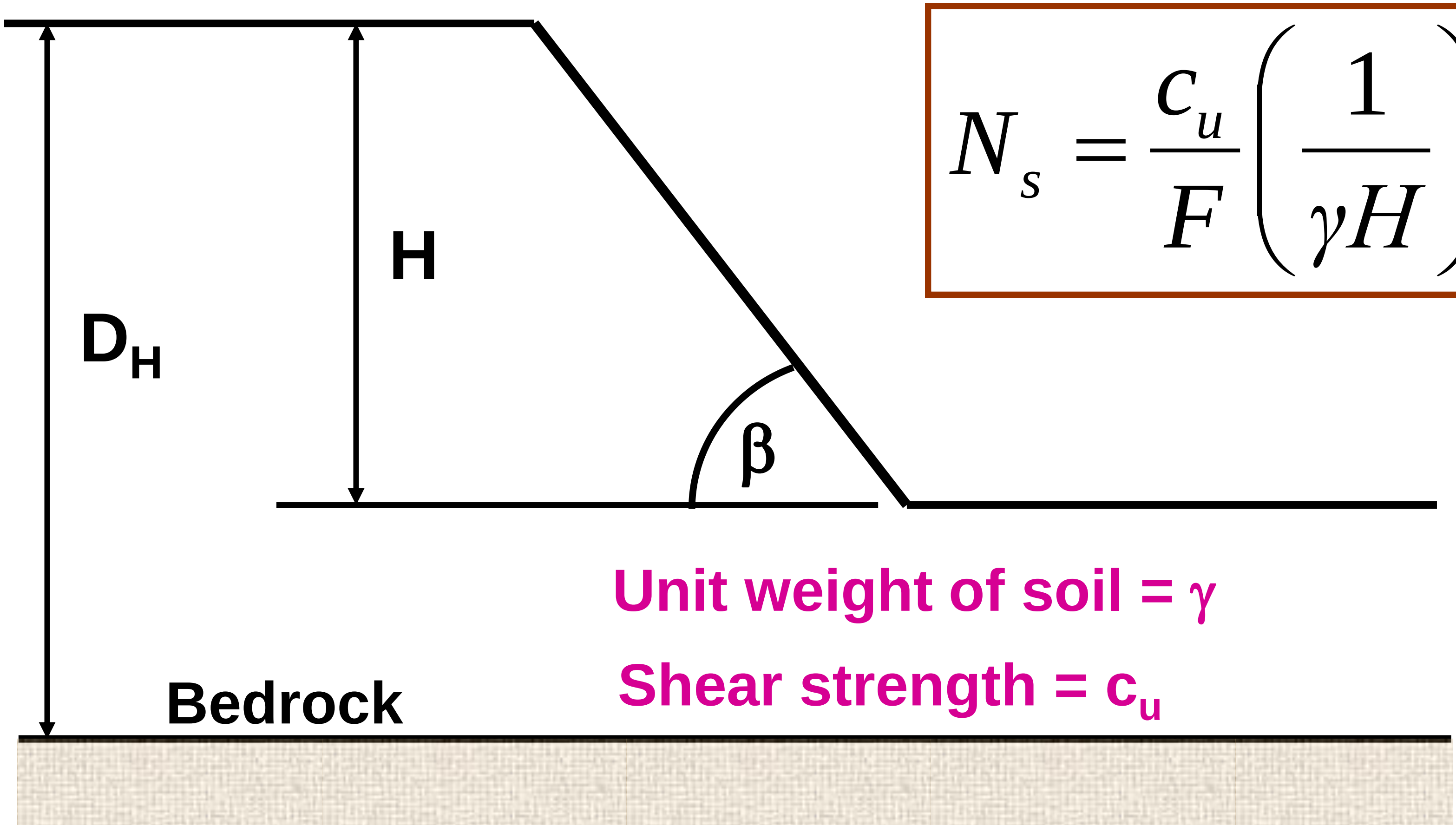
$$P_W = \frac{\gamma_w z_c^2}{2}$$

Taylor's Charts

- Simple slopes
- Homogeneous
- Dry slope or fully submerged slope

- <u>WARNING:</u> slopes are rarely homogeneous

Taylor's Charts – *F* = *F.S.*

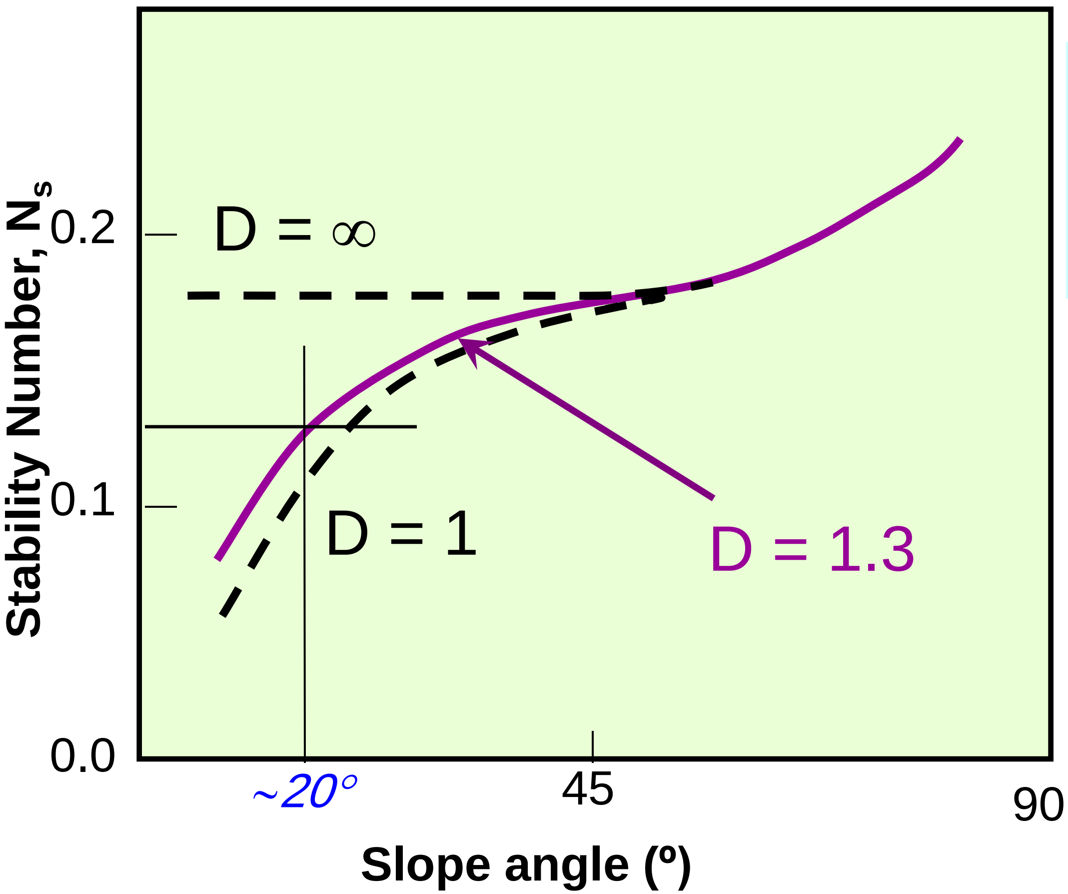


$$N_s = \frac{c_u}{F}\left(\frac{1}{\gamma H}\right)$$

Unit weight of soil = γ

Shear strength = c_u

Example (1)



H = 10 m, D_H = 13 m

Fs = 1.25

γ = 18 kN/m³, c_u = 30 kPa

$N_s = 30/[1.25(18)10]$
$= 30/225 = 0.133$

D = 13/10 = 1.3

$\beta = 20^o$

Example (3)

An embankment is to be made from a soil having $c' = 420$ lb/ft^2, $0' = 18°$ and $\gamma = 121$ lb/ft^3. *The* desired factor of safety with respect to cohesion as well as that with respect to friction is 1.5.

Determine

1 . The safe height if the desired slope is 2 horizontal to 1 vertical.

2. The safe slope angle if the desired height is 50 ft.

Example (3)

- $\tan \phi = \tan 18° = 0.325$,
- $\tan \phi_m = (\tan \phi)/1.50$
- $\phi_m = 12.23°$
- For $\phi_m = 12.23°$ and
- $\beta = 26.6°$ (i.e., 2 horizontal and 1 vertical)
- the chart gives $N_s = 0.055$
- c' =420

$$N_s = \frac{c}{F}\left(\frac{1}{\gamma H}\right) \qquad H = 42\,ft$$

Example (3)

$$N_s = \frac{c}{F}\left(\frac{1}{\gamma H}\right) = \frac{420}{1.50}\left(\frac{1}{121*50}\right) = 0.046$$

For ϕ_m = 12.23° and N_s = 0.055

the chart gives :

β = 23.50°

Summary: Key Points

a. Angle of repose for dry granular soils
b. Influence of seepage on granular soils
c. Slope stability for homogeneous slopes in saturated clay (NC)
    - simple analyses
    - Taylor's charts
d. Frictional soils more difficult
    - Method of slices
e. Slope stability programs use limit equilibrium

POINTS, continued

f. Slope stability programs search for the failure surface with lowest FoS
   - circular or non-circular slips?

g. Bishop’s simplified method for circular slips
   - further refinement unwarranted?

h. Importance of shear strength parameters
   - drained and/or undrained?
   - peak, ultimate or critical state?