Tutorial video 1: Introduction

Deep Excavation LLC
INTRODUCTION

DeepXcav 2010 is a software program for braced excavations in soils with 2D limit-equilibrium and non-linear analysis methods, and structural verification of all elements (with AISC, ASD, Eurocodes).

It offers the ability to analyze walls with multiple braces (tiebacks) in multilayered soils.

The non-linear analysis considers elastoplastic behavior for the whole soil-wall-support system.

The program also offers the ability to perform traditional limit-equilibrium analyses.

The graphical interface is completely interactive and the input is simplified to a great extend.

The program utilizes archives of wall types, structural and soil materials, ground anchors etc.

The analysis can be performed in either an ultimate state or at a service state (allowable design or LRFD).

The program offers the ability to automatically set all critical settings according to the desired design methodology.
Enter basic project information

1. Select this button
2. Define the project name etc.
3. Change units to English
4. Press OK
Water density recommendation

In metric units the water density is typically taken as 10 kN/m³. This value is slightly greater than the fresh water density of 62.4 pcf that is typically assumed.

Press YES
Move model elevations

1. Select this button

2. Set new reference elevation to 100 ft

3. Check All boreholes (this moves all soil layers)

4. Press OK
Define basic model limits (top, bottom, left, right)

1. Select this button

2. Set Top = 130 ft
   Bottom = 40 ft
   Left = -60 ft
   Right = 60 ft

3. Press OK
Modify soil types (database of soils)

1. Go to Properties tab
2. Select this button.
   Or

Expand the Soils Tree and Double click on F
Options: Right click or press Delete

Note: In DeepXcav you can use any soil type in more than one borehole. For example, the F soil can be used in boring 1 or boring 2 etc.

You can use any Boring on any design section. Thus changing any property of the F soil will affect all the excavation Design Sections where F is used!
Soil type data form

Short soil name, description and color.

Available soil types

Soil type & initial clay behavior

Density

Strength

Permeability

Test data for estimating soil properties

Add new, copy, delete, paste soil

DeepXcav 2010 – Advanced course
Soil properties: General

Soil name: F (this appears in the boring)
Description: Detailed soil description.
Soil type: Sand
$\gamma_t = 120$ pcf : Total unit weight
$\gamma_{dry} = 115$ pcf : Dry unit weight (above water table)
$c' = 50$ psf : Effective cohesion
$\phi' = 30$ degrees : Effective friction angle

$\nu = 0.35$ Poisson's ratio

$K_x = $ Horizontal permeability
$K_z = $ Vertical permeability

Parameters only for clays
$S_u = $ Undrained shear strength
$\phi_{cv} = $ Constant volume shearing angle
$\phi_{peak} = $ Peak shearing angle
Soil properties (Resistance and Elastic)

KaP and KpP used only in Non-Linear analysis. Leave default values.

KoNC = At rest lateral earth pressure coefficient for normally consolidated state.

Enter elasticity values as shown before. Click on > buttons for more options.
Bond resistance for ground anchors.

Soil properties will be covered in more detail in Training Course #2.

Enter ultimate skin friction (bond resistance) for tiebacks (ground anchors). Value is later divided by safety factor to obtain design capacity on each tieback.
Soil S1

Soil properties: Change S1

A. General
Soil name: S1 (this appears in the boring)
Description: Sand
Detailed soil description.
Soil type: Sand
\( \gamma_t = 125 \text{pcf} \): Total unit weight
\( \gamma_{dry} = 120 \text{pcf} \): Dry unit
\( c' = 50 \text{psf} \): Effective cohesion
\( \Phi' = 36 \text{degrees} \): Effective friction angle
\( V = 0.35 \): Poisson's ratio

C. Elasto-plastic
\( E = 600 \text{ksf} \)
\( Eur = 1800 \text{ksf} \)

D. Bond
Ultimate bond = 40 psi

Press OK
Edit Borings (soil layers)

To edit the soil layers double click on the model boring.

The borings can also be edited from:

a) Properties Tab: Then Borings Button.

Or from the:

b) Tree View - Stratigraphy - boreholes

Double click here (or right click) with the mouse.
Enter Soil Layers

To edit the soil layers click on the blue button and enter the top of layer elevation.

For this example type 90 here:

Then select soil type S1 here:
Enter Soil Layers

Press OK
Corso Paratie, Milano 30 settembre 2009
Change water table elevation to El. 85ft

Ground water levels can be changed from the Model Tab.

Or

By double clicking on the water table on the model screen.

Double click on button or on water table.
1. Change water levels to 85ft

2. Select option

3. Select option for analysis type

4. Press OK
Double click on wall
1. Change wall depth to 40ft

2. Select edit section data, to change wall properties
Change wall section AZ 19 sheet pile

1. Change wall type
2. Select AZ-19 section
3. Select A50 steel (\(fy = 50\) ksi)
4. Select OK
Wall using AZ-19 wall section

Select OK
Add a new stage (Model Tab)

Or right click (to add a stage, similar to Excel)
Model tab: Stage 1 change right El. 90
Add Stage 2: Add a tieback at El. +92

Right click and add stage 2
Select tool to add a tieback

Note: Program tells you to select/enter the 1st tieback point at the wall (x z)
Add tieback with mouse

1. Select 1st point on wall (we will modify the coordinates later)

2. Select 2nd point in the soil

3. Double click on new tieback
Edit tieback properties (support options)

1. Change dimensions
   \( z = 92 \text{ ft} \) (elevation)
   \( L_{\text{free}} = 16 \text{ ft} \), \( L_{\text{fix}} = 25 \text{ ft} \), \( \alpha = 20 \text{ deg} \), spacing 8\text{ ft} 

2. Check adjust prestress option and use 80 kip prestress.

Select OK
Corso Paratie, Milano 30 settembre 2009
Add a surcharge on the surface. Select this tool button.
Add surcharge with mouse

1. Select 1st point on left
2. Select 2nd point on right
3. Double click on new surcharge
Modify surcharge

1. Change coordinates
   \[ X_1 = -20 \quad X_2 = -2 \]

2. Change surcharge
   \[ qz_1 = 0.6 \text{ ksf}, \quad qz_2 = 0.6 \text{ ksf} \]

Point 1 is on the left side
Point 2 is on the right side

3. Select OK
Add stage 3: Excavate to El. 80ft

Right click and add stage 3
Stage 3:
Excavate El. 80ft, lower right water to El. 80ft
On stage 3: Go to Analysis tab

1. Change analysis mode to Conventional (Traditional limit equilibrium analysis)
Analysis tab: Change wall friction

1. **Change wall friction behavior**
   - (wall friction % of soil friction)
   - Set 1st wall friction to zero
   - % of soil friction
   - Specific Value (deg)
   - Vertical adhesion on Su driving
   - Vertical adhesion on Su resisting

2. **Change wall friction to 50%**
   - (of available soil friction)
   - Select Coulomb equation for wall friction
   - (log-spiral failure) Select Yes to apply on all Stages!

3. **Select Coulomb equation for wall friction**
   - (Driving side is the retained side)
   - Select Yes to apply on all Stages!
Analysis Tab Stage 3:
Change earth pressure assumptions (Limit equilibrium)

1. Select Peck earth pressures for Stage 3
2. Select resisting earth pressures
   Passive divided by safety factor FS
3. Double click on Button for more options
4. Apply to all stages
Select US structural codes (Design Tab)

1. Select US allowable settings from Design tab
Review Assumptions (Yellow table Stage 2)

1. Concrete code and Steel Code
2. Clay behavior
3. Water pressure analysis
4. Driving pressures \( K_a + d\cdot\text{Coul} = \text{Active with coulomb wall friction} \)
5. Resisting pressures \( K_p/1.5 + D\cdot\text{Caquot} = \text{Passive divided by 1.5 with Caquot-Kerisel wall friction} \)

Review Assumptions (Yellow table Stage 3)
Analyze the model
### Summary Table (all Design Sections)

<table>
<thead>
<tr>
<th>Calculation Result</th>
<th>Wall Displacement (m)</th>
<th>Settlement (mm)</th>
<th>Wall Moment (kN-m)</th>
<th>Wall Shear (kN)</th>
<th>STR Wall Ratio</th>
<th>STR Moment Wall Ratio</th>
<th>STR Shear Wall Ratio</th>
<th>Wall Concrete Service Stress (MPa)</th>
<th>Wall Reinforcement Stress (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base model</td>
<td>Calculation success</td>
<td>0.09</td>
<td>3.03</td>
<td>13.03</td>
<td>13.03</td>
<td>4.72</td>
<td>4.72</td>
<td>0.072</td>
<td>0.072</td>
</tr>
</tbody>
</table>

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### Summary table (Selected design section all stages)

<table>
<thead>
<tr>
<th>Calculation Result</th>
<th>Wall Diplocem (in)</th>
<th>Siltson (in)</th>
<th>Wall Moment (k-ft)</th>
<th>Wall Moment (k-in)</th>
<th>Wall Shear (k)</th>
<th>Wall Shear (k)</th>
<th>STR Combine Wall Ratio</th>
<th>STR Combine Wall Ratio</th>
<th>Concrete Service Wall Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 0</td>
<td>Calculated</td>
<td>0</td>
<td>N/A</td>
<td>0</td>
<td>0.04</td>
<td>0.04</td>
<td>0</td>
<td>0</td>
<td>0.001</td>
</tr>
<tr>
<td>Stage 1</td>
<td>Calculated</td>
<td>0.06</td>
<td>0.1</td>
<td>4.95</td>
<td>4.95</td>
<td>4.72</td>
<td>4.72</td>
<td>0.027</td>
<td>0.083</td>
</tr>
<tr>
<td>Stage 2</td>
<td>Calculated</td>
<td>0.03</td>
<td>0.11</td>
<td>7.04</td>
<td>7.04</td>
<td>2.13</td>
<td>2.13</td>
<td>0.039</td>
<td>0.083</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Calculated</td>
<td>0.09</td>
<td>0.3</td>
<td>13.03</td>
<td>13.03</td>
<td>3.96</td>
<td>3.96</td>
<td>0.072</td>
<td>0.078</td>
</tr>
</tbody>
</table>

**Note:** You may select another design section or another wall (when a 2nd wall is used) Press EXIT
Results Tab
(for viewing results on model screen)

- Wall embedment and other safety factors
- Wall moment, shear, axial, displacement. Support reaction R.
- Display wall capacity (moment and shear), Stress ratios (ratios <1 OK)
- Display stresses and pressures on walls.
- Display soil mass stresses (when water flownet analysis is performed)
- Click on Min-Max to display min and max values. Show ENV= Show result envelope (this design section)
View moment and shear
View moment and wall moment capacity

Red lines represent the design moment capacity for this wall.
Support reaction and lateral soil stress and...
View embedment safety factors
Add 2\textsuperscript{nd} Design section and perform non-linear analysis

1. Right click on Base model
   Select Add Section

2. Double click on New Section 1
Right click on New Section 1 (edit section name)

Change the name for the new design section to Non-linear analysis
Design Section name has changed (now you are working on Design Section 1)
Analysis Tab: Type-> Select Conventional and Beam Elastoplastic Foundations
Analyze All Design Sections
Extended Summary two design sections

<table>
<thead>
<tr>
<th>Extended Summary</th>
<th>Calculation Result</th>
<th>Wall Displacement (in)</th>
<th>Sett Nonlinear 1.42</th>
<th>Wall Moment (k-ft)</th>
<th>Wall Shear (k-ft)</th>
<th>Wall Shear (k)</th>
<th>STR Combine Wall Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base model</td>
<td>Calculation success</td>
<td>0.09</td>
<td>0.3</td>
<td>18.54</td>
<td>18.54</td>
<td>4.96</td>
<td>4.96</td>
</tr>
<tr>
<td>Non linear analysis</td>
<td>Calculation success</td>
<td>0.23</td>
<td>0.14</td>
<td>14.4</td>
<td>14.4</td>
<td>4.77</td>
<td>4.77</td>
</tr>
</tbody>
</table>
Stage 0: Wall displacements – Support Reactions

Please select Stage 0
Stage 1: Wall displacements – Support Reactions

Please select Stage 1  
(Horizontal displacement = 0.23 inches)
Stage 2: Wall displacements – Support Reactions

Please select Stage 1       (Horizontal displacement = 0.23 inches)
Stage 2: Wall displacements – Support Reactions

Please select Stage 2  
(Horizontal displacement reduced due to tieback prestress)

Support reaction  
10 klf  
Equal to tieback prestress
Stage 3: Wall displacements – Support Reactions

Please select Stage 3 (Horizontal displacements increased = 0.15 inches)

Support reaction 10.19 klf
Tieback stress ratios (Load/Capacity)

GEO = Geotechnical stress ratio 0.732<1 OK
STR = Structural stress ratio 0.581<1 OK

Please select Stage 3
View embedment safety factors

Limit equilibrium analysis safety factors
- FS Embed = Based on length
- FS Rot = Based on rotation moments
- FS Basal = Basal stability
- FS Hyd = Hydraulic heave

Non-linear analysis safety factors
- Passive mob FS= Available passive resistance / Mobilized passive
- Active mob FS= Mobilized active / min. active earth pressures.