P-PPAK
The Pile-Pile/Soil interactions Package

How to use P-PPAK with simple two examples for Piled raft

The P-PPAK is an add-in tool to the PLPAK that allows simulation of pile-pile/soil interactions effects underneath piled rafts.

P-PPAK consider three types of interaction effects:

	Piles DOFs	**Soil DOFs**
Piles DOFs	P-P interactions (1)	P-S interactions (3)
Soil DOFs	S-P interactions (3)	S-S interactions (2)

1- Consider Pile-pile interaction effects (P-P). These interaction effects could be considered using elastic approach, load transfer approach or user field measurements interaction factors. In case of multi-layered soil, these interactions are considered using three different approach:

a- Average soil young's modulus (E_{avg}) between two points each has its layer's young's modulus E.

b- Equivalent soil young's modulus (E_{equ}) for all layers.

c- Modified soil young's modulus (E_{mod}) using Poulos and LEE modifications.

2- Consider soil-soil interaction effects (S-S). These interaction effects could be considered using EHSPAK.

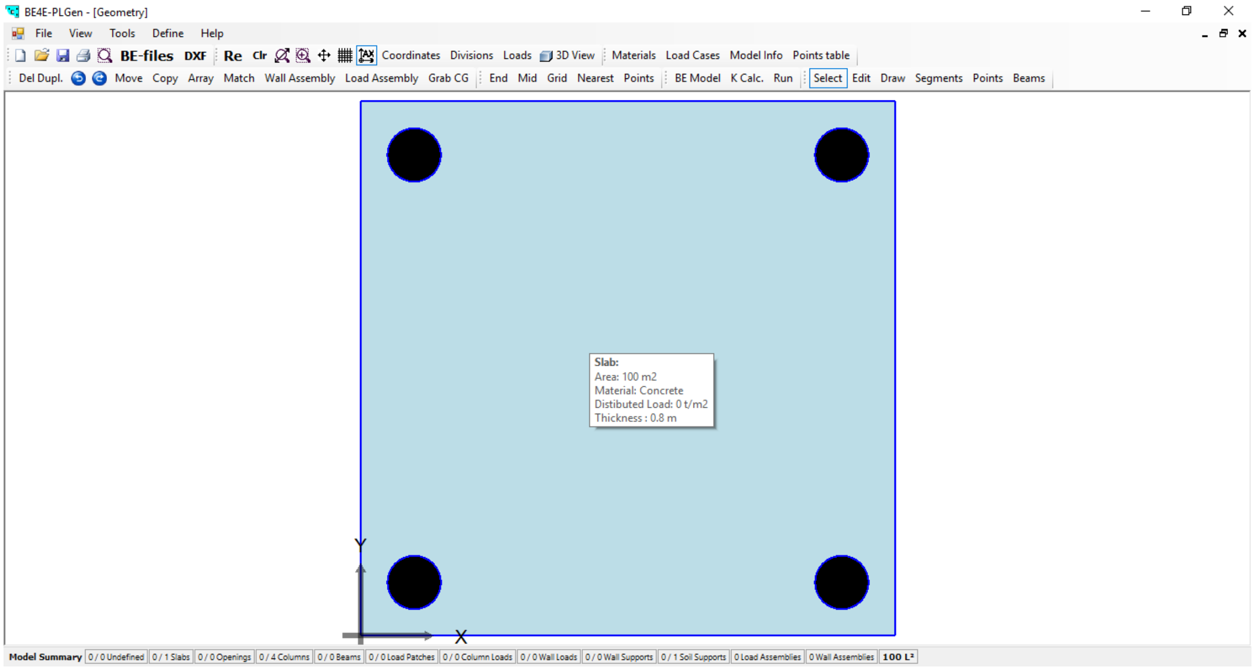
3- Consider Pile-soil interaction effects (P-S). These interaction effects could be considered using Mindlin's solution. Also, in case of multi-layered soil, the same three approaches in (1) are used.

For more clarification, The P-PPAK is described using simple two examples. For different input files structures see appendix 2.

<u>Problem 1:</u>

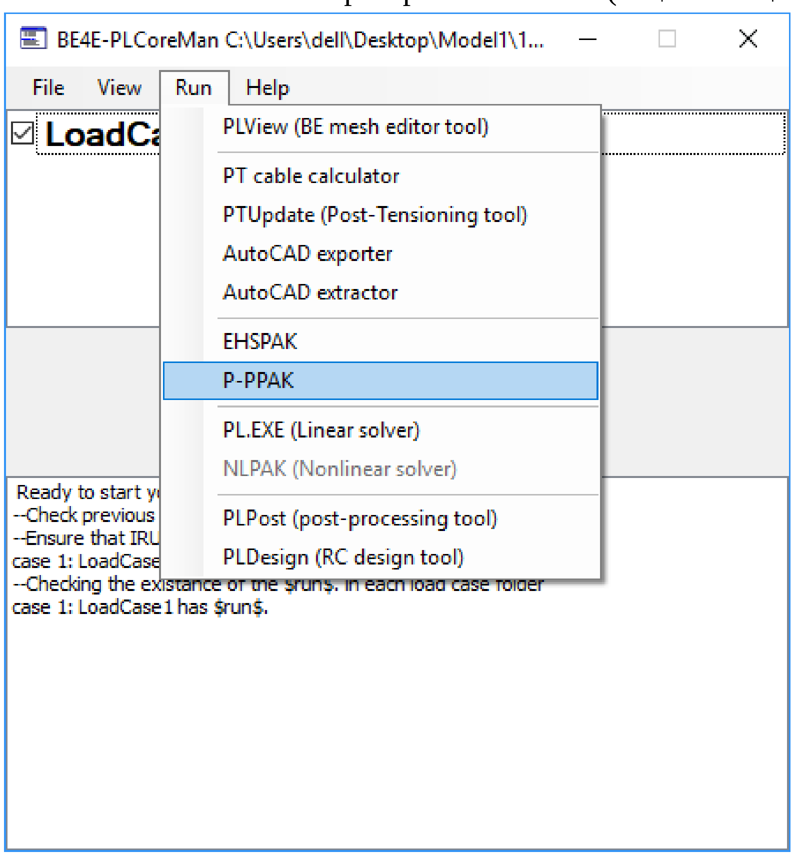
This problem is 10 × 10 m piled raft with thickness 0.8 m supported on four piles each 0.5 m radius subjected to its own weight.

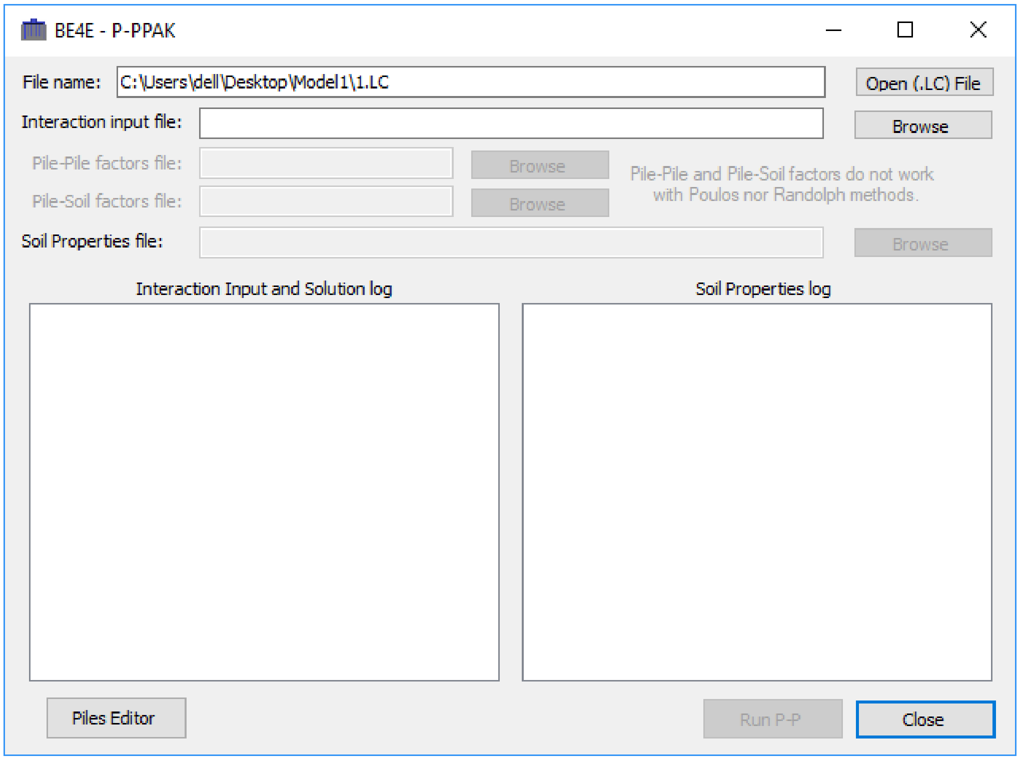
1- Generate Gen model.



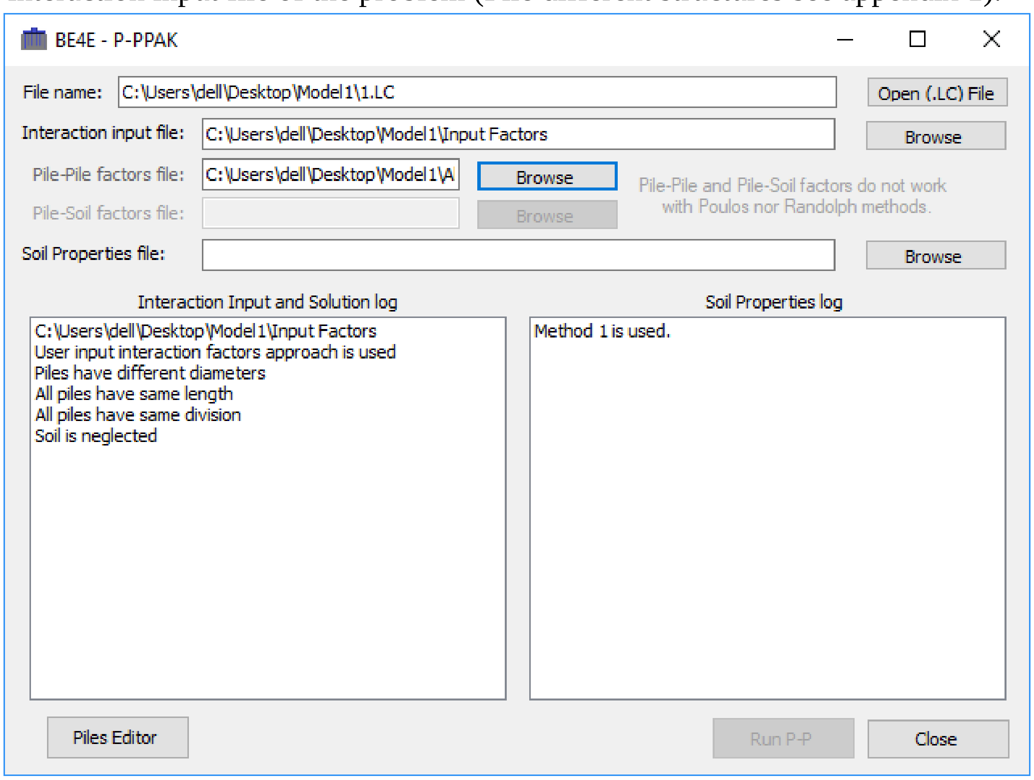
2- Run the problem from PLGen or load it from PLCoreMan.

3- From PLCoreMan run P-PPAK to extract pile-pile stiffness in (PL$MATK$.-4).

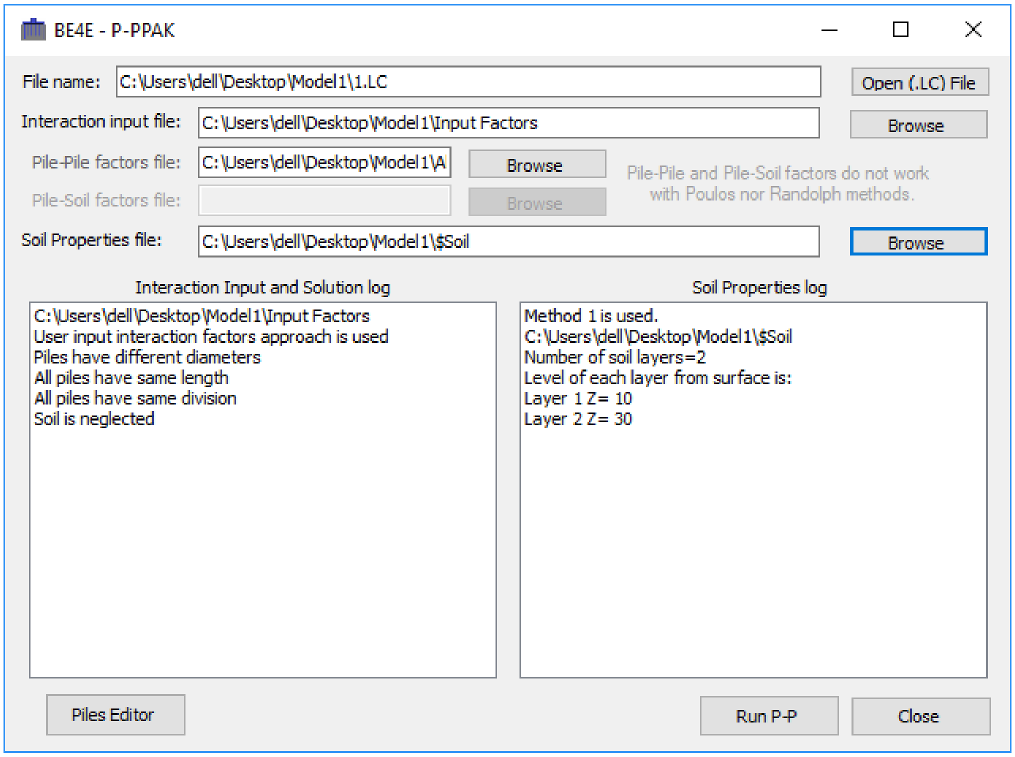




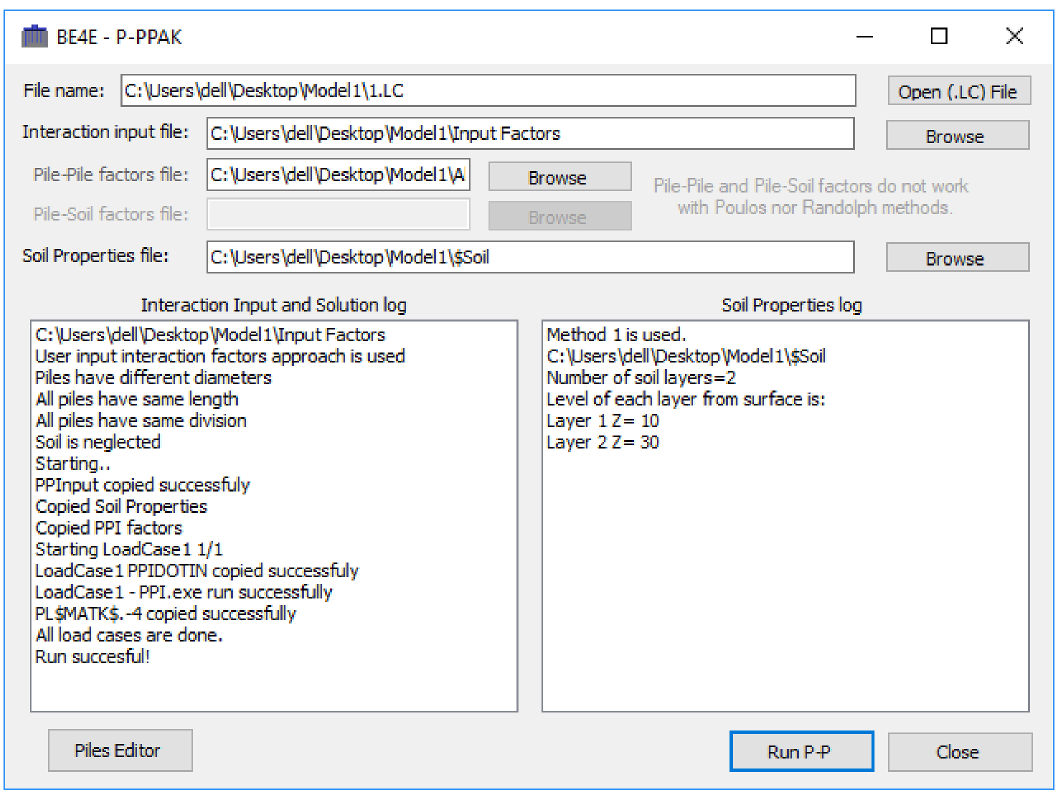
a. Load interaction input file of the problem (File different structures see appendix 1).



b. Load soil properties file (File format see appendix 1).

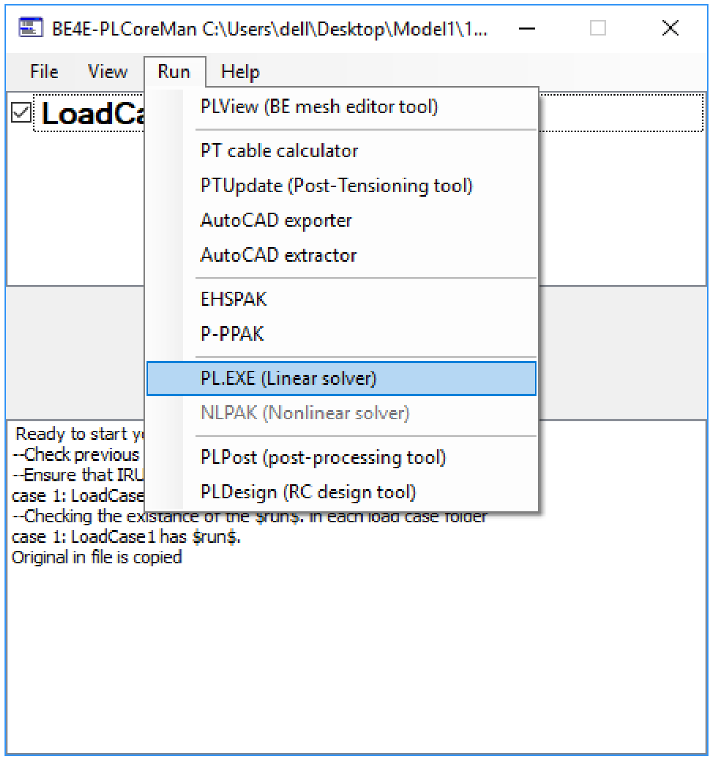


c. Press button Run P-P

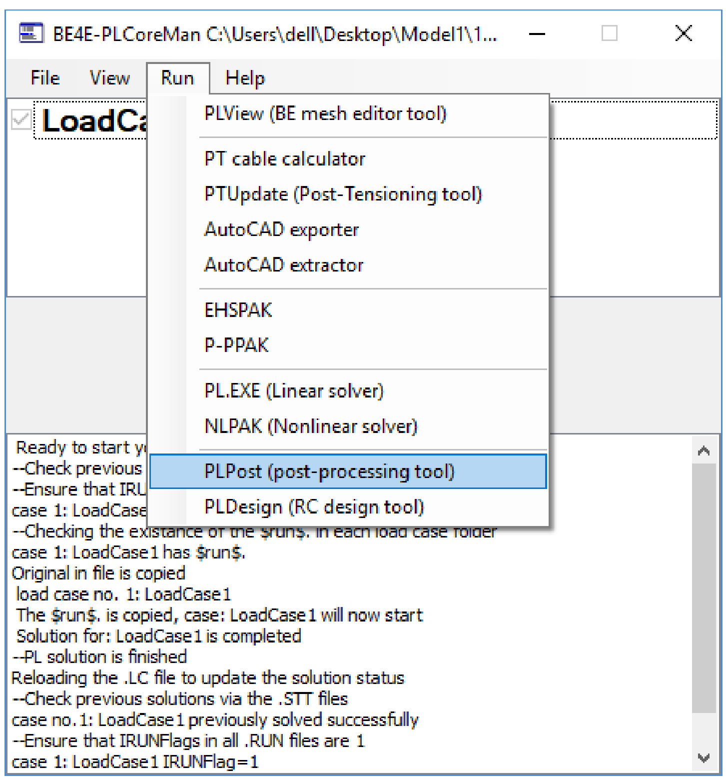


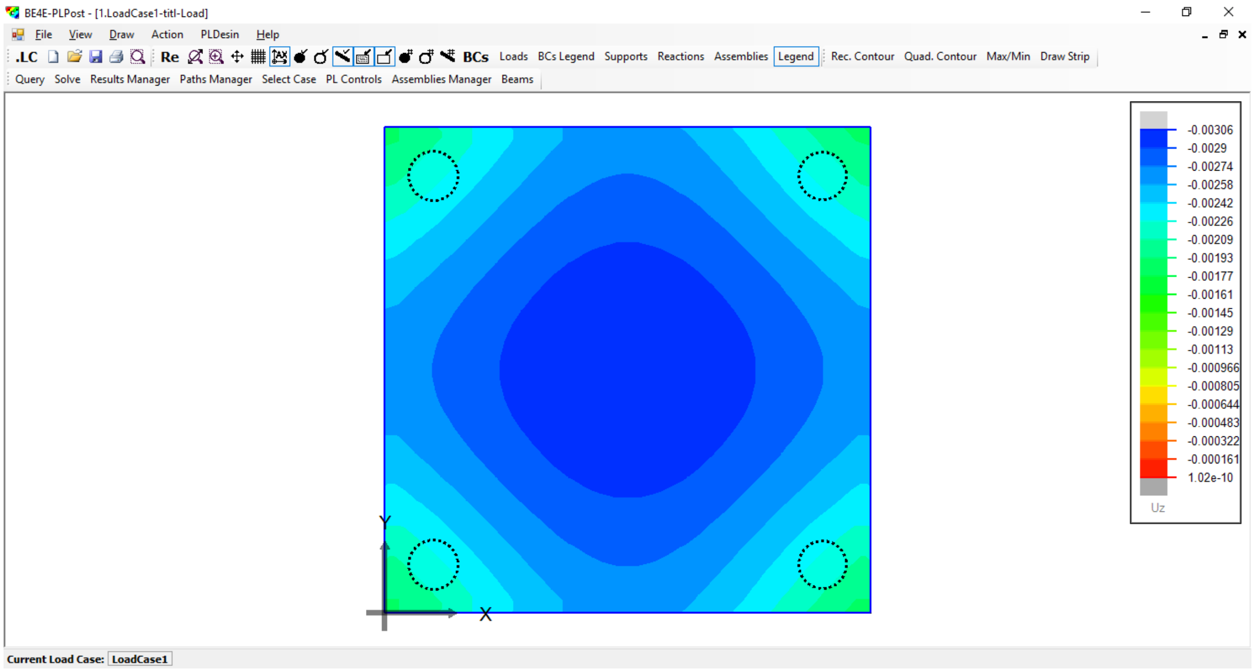
4- Close P-PPAK and go back to PLCoreMan.

5- Run PL.exe (Linear solver).



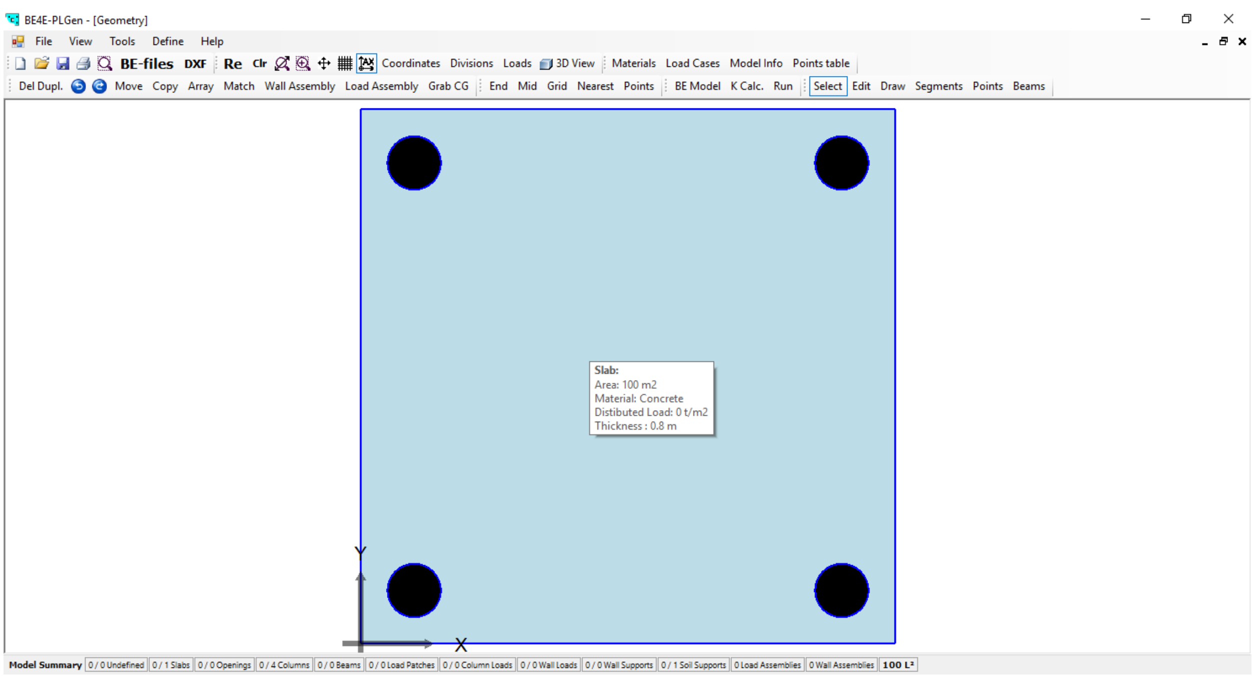
6- Show results on PLPost.





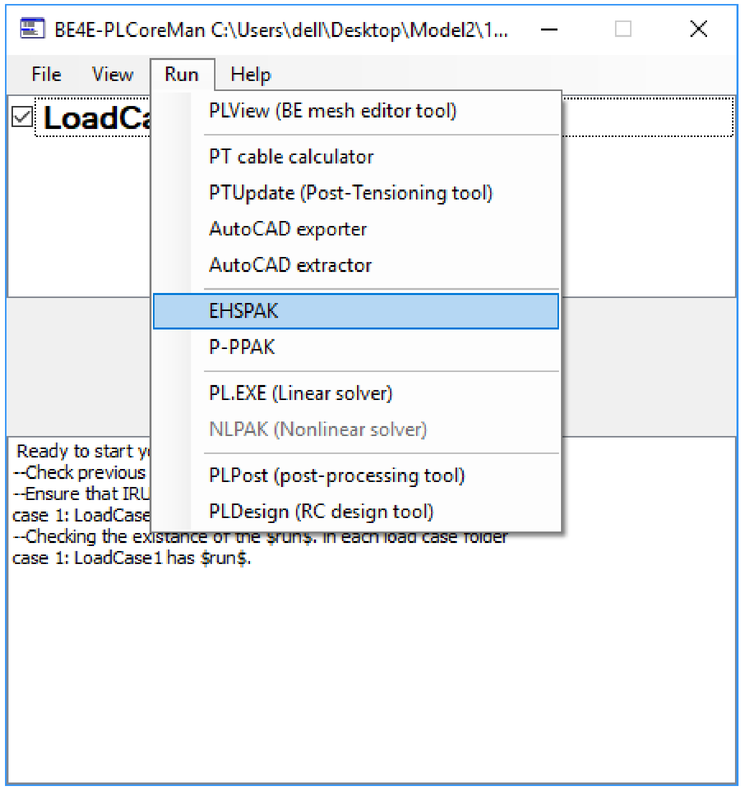
Problem 2: This problem is 10 × 10 m piled raft with thickness 0.8 m supported on four piles each 0.5 m radius and two-layered elastic half space subjected to its own weight.

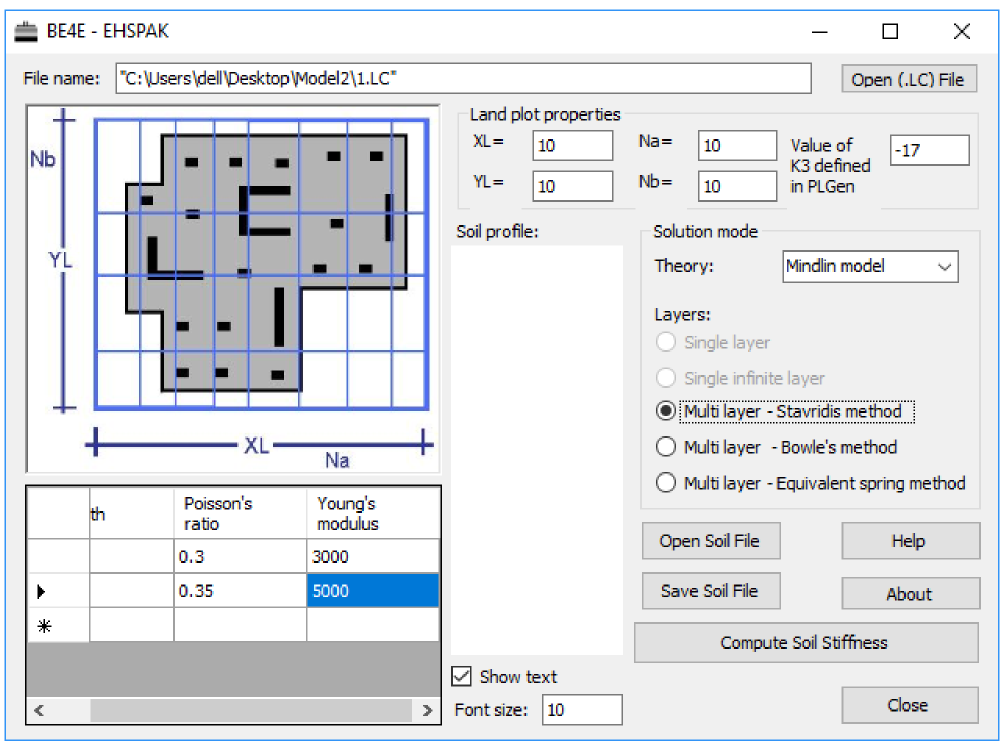
1- Generate Gen model.

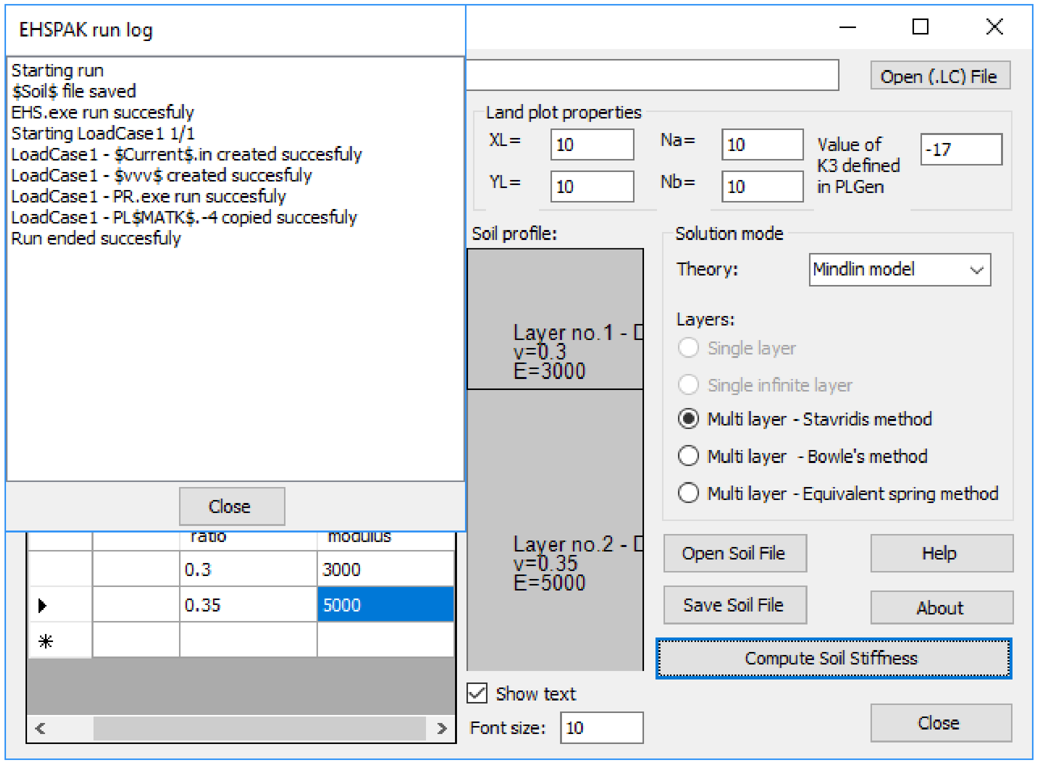


2- Run the problem from PLGen or load it from PLCoreMan.

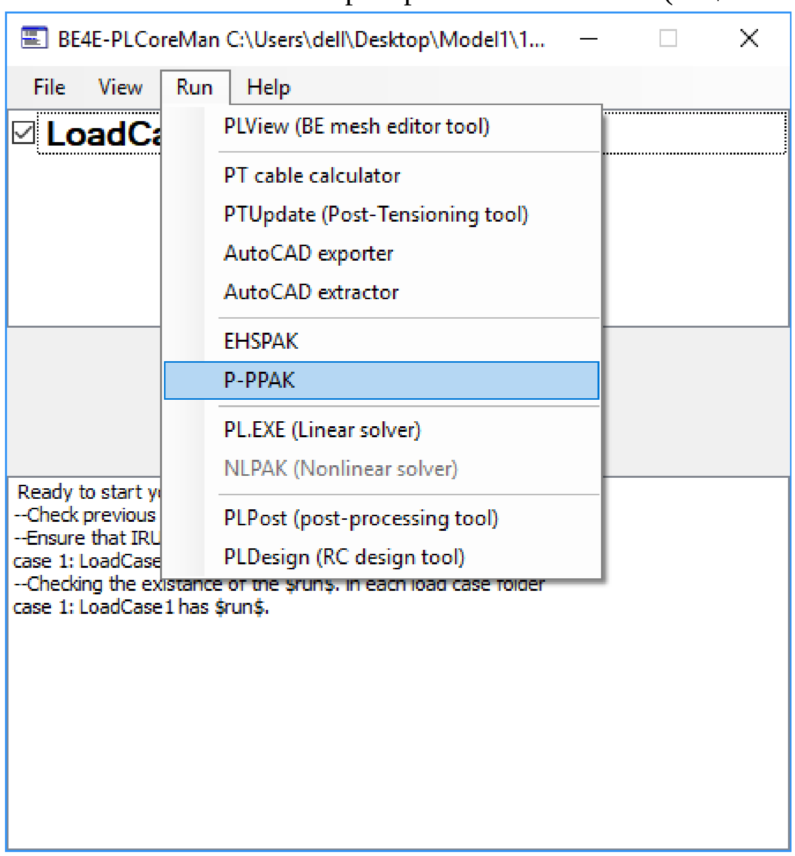
3- From PLCoreMan run EHSPAK to extract soil-soil stiffness in (PL$MATK$.-4).

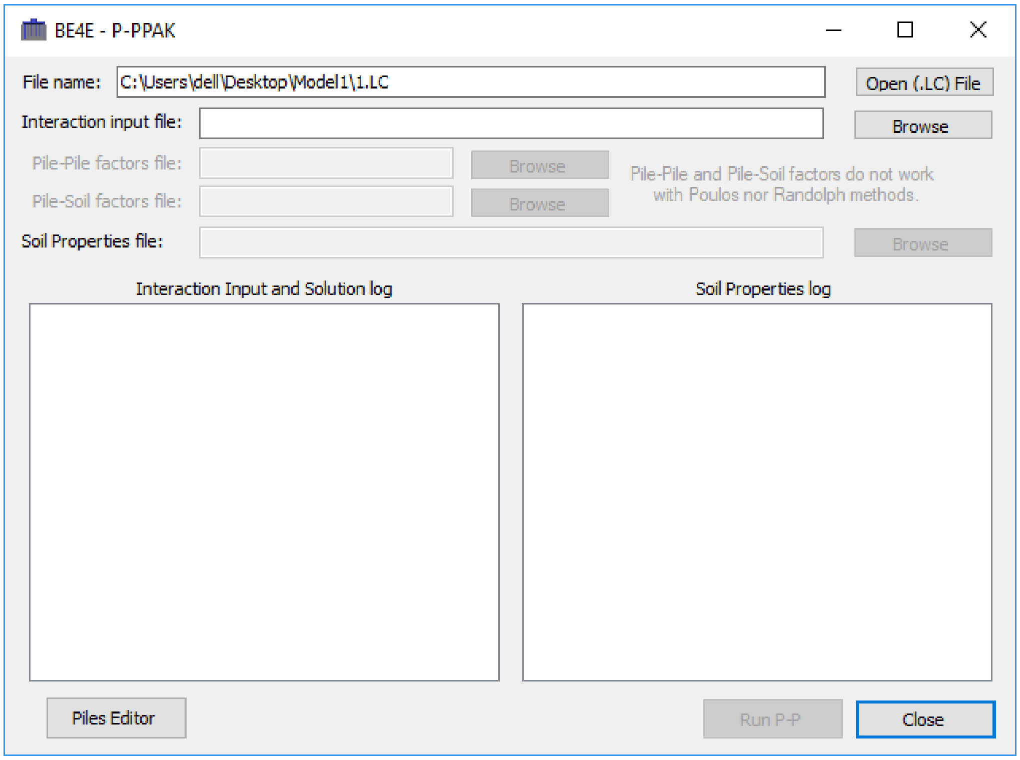

BE4E-PLCoreMan C:\Users\dell\Desktop\Model2\1...
File
View
Run
Help
LoadCa
PLView (BE mesh editor tool)
PT cable calculator
PTUpdate (Post-Tensioning tool)
AutoCAD exporter
AutoCAD extractor
EHSPAK
P-PPAK
PL.EXE (Linear solver)
NLPAK (Nonlinear solver)
PLPost (post-processing tool)
PLDesign (RC design tool)
Ready to start y
--Check previous
--Ensure that IRU
case 1: LoadCase
case 1: LoadCase1 has run.


BE4E - EHSPAK
File name:
"C:\Users\dell\Desktop\Model2\1.LC"
Open (.LC) File
Nb
YL
XL
Na
Land plot properties
XL=
10
YL=
10
Na=
10
Nb=
10
Value of K3 defined in PLGen
-17
Soil profile:
Solution mode
Theory:
Mindlin model
Layers:
Single layer
Single infinite layer
Multi layer - Stavridis method
Multi layer - Bowle's method
Multi layer - Equivalent spring method
th
Poisson's ratio
Young's modulus
0.3
3000
0.35
5000
Open Soil File
Help
Save Soil File
About
Compute Soil Stiffness
Show text
Font size:
10
Close

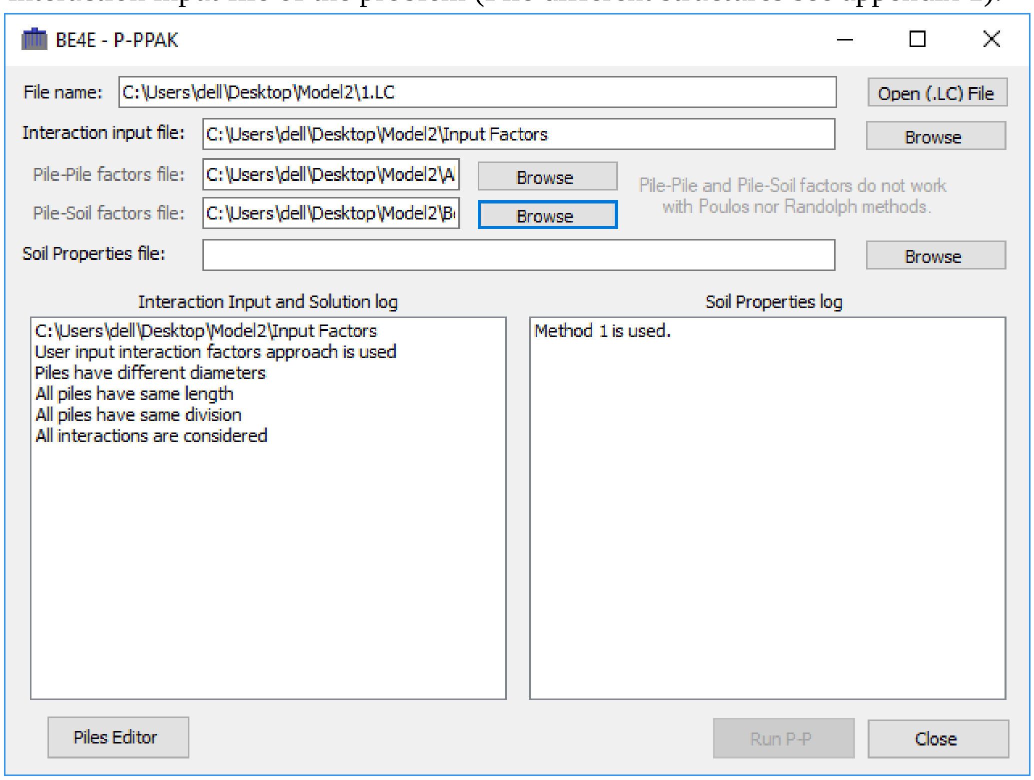


4- From PLCoreMan run P-PPAK to extract pile-pile/soil stiffness in (PL$MATK$.-4).

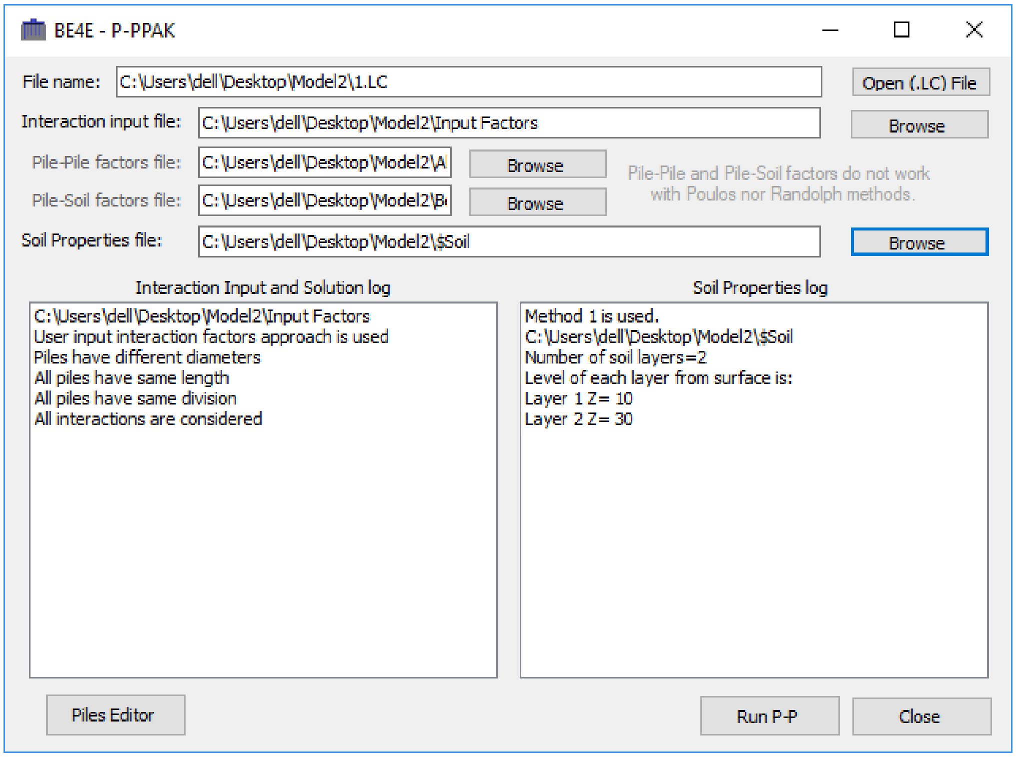




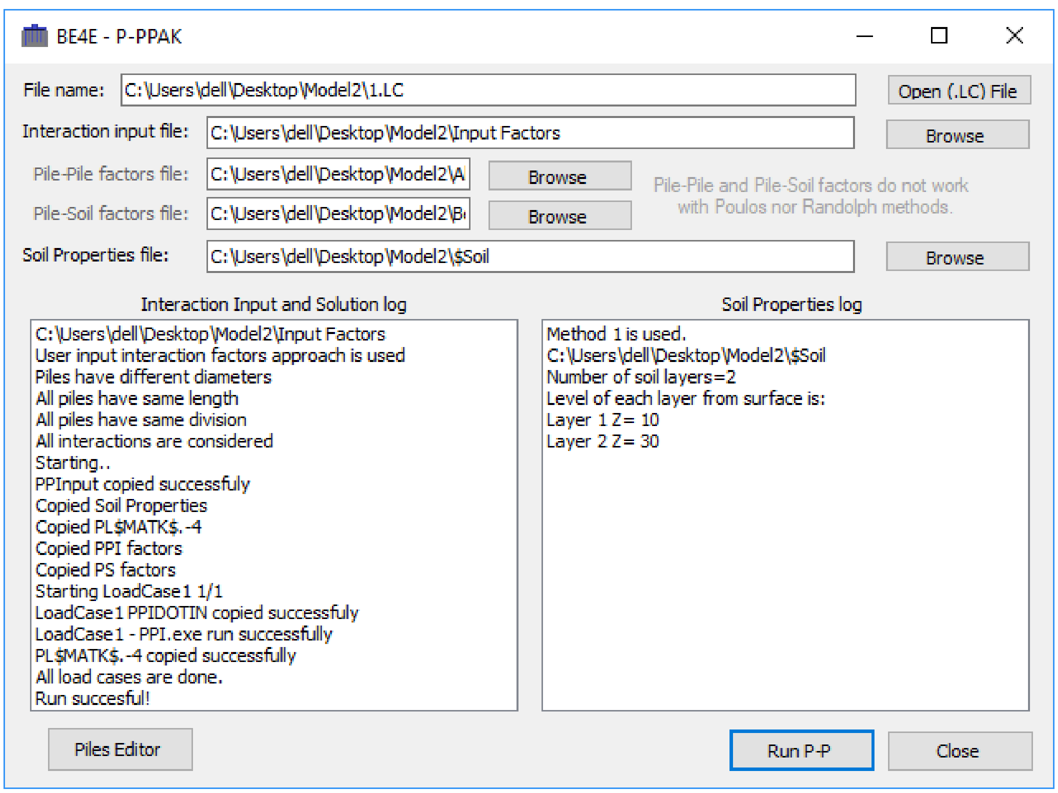
a. Load interaction input file of the problem (File different structures see appendix 1).



b. Load soil properties file (File format see appendix 1).

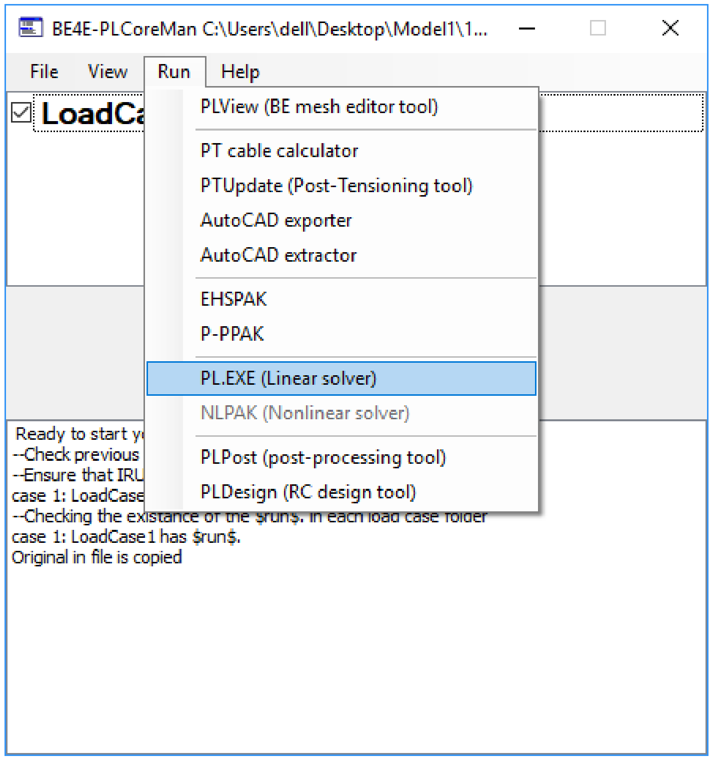


c. Press button Run P-P

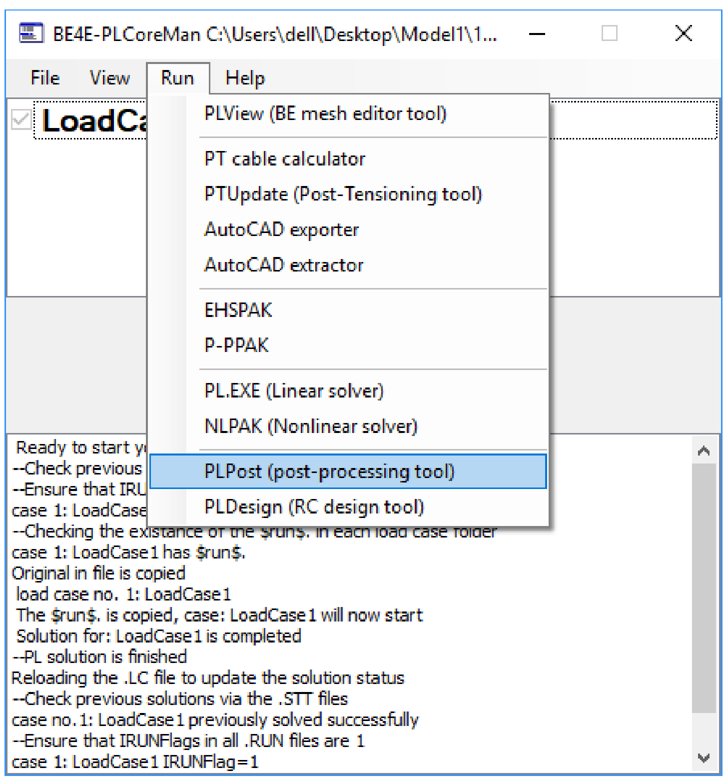


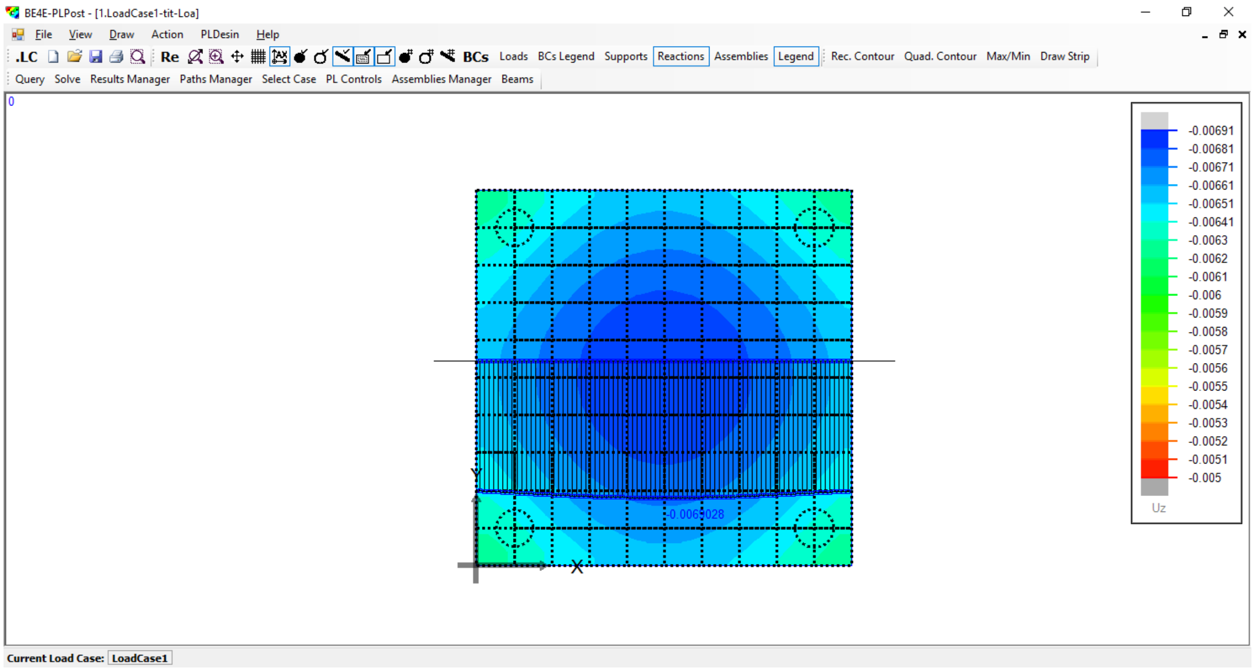
5- Close P-PPAK and go back to PLCoreMan.

6- Run PL.exe (Linear solver).



7- Show results on PLPost.




BE4E-PLPost - [1.LoadCase1-tit-Loa]
File View Draw Action PLDesin Help
.LC Re BCs Loads BCs Legend Supports Reactions Assemblies Legend Rec. Contour Quad. Contour Max/Min Draw Strip
Query Solve Results Manager Paths Manager Select Case PL Controls Assemblies Manager Beams
-0.00691
-0.00681
-0.00671
-0.00661
-0.00651
-0.00641
-0.0063
-0.0062
-0.0061
-0.006
-0.0059
-0.0058
-0.0057
-0.0056
-0.0055
-0.0054
-0.0053
-0.0052
-0.0051
-0.005
Uz
X
Current Load Case: LoadCase1

Appendix 1
Input files Structure

1- Interaction input file:

- **0/1/2** 0: if load transfer approach, 1: if elastic approach, 2: if user input interaction approach.
- **N_p** Total number of piles.
- **r_1**
  r_2
  .
  .
  .
  .
  r_{Np}
  } Radius for each pile.
- **L_1,d_1**
  L_2,d_2
  .
  .
  .
  .
  L_{Np},d_{Np}
  } Length and number of divisions for each pile.
  (Note: Load transfer approach method, piles have the same length and same divisions.)
  i.e. this part will be only one line in this case **(L, d)**.
- **F_1**
  F_2
  .
  .
  .
  .
  F_m
  } Factors for including or neglect friction or end bearing (see Figure A).
  ($m = \sum d(i) + 2N_p$) $i=1 \rightarrow N_p$
  (Note: These factors are in cases load transfer approach and elastic approach only.)
- **E_{p1}**
  E_{p2}
  .
  .
  .
  .
  E_{pNp}
  } Young's modulus for each pile.
- **0/1/2** 0: for including P-P interactions only, 1: for including P-P and S-S interactions only (neglecting P-S interactions), 2: for including all interactions (P-P, S-S, P-S).
- **Layering method 1/2/3.** 1: Average E, 2: Equivalent E, 3: Poulos and Lee – (Modified E).

1.1. Pile-pile factors file (α):

- **1/2/3** 1: U_{ii} read from this file, 2: U_{ii} calculated from load transfer approach, 3: U_{ii} calculated from elastic approach.
- $\mathbf{U_1}$, $\mathbf{U_2}$, ... $\mathbf{U_{Np}}$ } U_{ii} for each pile. (Exist only in case of U_{ii} read from this file" i.e. the first line is 1").
- $\boldsymbol{\alpha_{11}}$, $\boldsymbol{\alpha_{12}}$, ... $\boldsymbol{\alpha_{(Np*Np)}}$ } $[\boldsymbol{\alpha}]_{\mathbf{Np*Np}}$ pile-pile interaction factors matrix as % from U_{ii} written as a one column.

1.2. Pile-soil factors file (β):

- **1/2** 1: U_{ii} read from this file, 2: U_{ii} calculated from EHSPAK.
- $\mathbf{U_1}$, $\mathbf{U_2}$, ... $\mathbf{U_{Np}}$ } U_{ii} for each soil cell. (Exist only in case of U_{ii} read from this file "i.e. the first line is 1").
- $\boldsymbol{\beta_{11}}$, $\boldsymbol{\beta_{12}}$, ... $\boldsymbol{\beta_{(Np*Nhs)}}$ } $[\boldsymbol{\beta}]_{\mathbf{Np*Nhs}}$ pile-soil interaction factors matrix as % from U_{ii} written as a one column (row_1, row_2 . . . $row_{\mathbf{Np}}$). (Note: $\mathbf{N_{hs}}$ is the total number of half space soil cells.)

2- Soil properties file (This file already exist in case of running EHSPAK before P-PPAK. Its name is $soil$ @ PLPAK folder):

- $\mathbf{N_{layers}}$,**Idum**, **Idum** Total number of soil layers, Any two dummy integer numbers.
- **Idum**, **Idum** Any two dummy integer numbers.
- $\mathbf{H_L}$,$\mathbf{E_s}$, $\boldsymbol{\upsilon_s}$, $\mathbf{H_L}$,$\mathbf{E_s}$, $\boldsymbol{\upsilon_s}$, . . . $\mathbf{H_L}$,$\mathbf{E_s}$, $\boldsymbol{\upsilon_s}$ } Layer soil modulus, Layer's poison's ratio, Layer depth from soil top surface.

Friction or End bearing factors

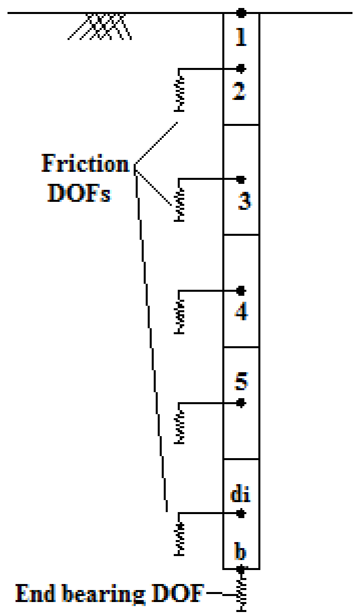


Figure A: Pile (i) friction and end bearing DOFs.

DOF 1: for connecting with the raft.

DOFs (2 to d_i): Friction DOFs.

DOF b: End bearing DOF.

Each pile has (d_i(number of divisions)+2(top and bottom)) DOFs.

All piles has m DOFs = $\sum d(i) + 2N_p$.

Several examples for write one pile factors in Interaction input file:

1 1 1 1 1 1 0 Friction pile(i) factors	0 0 0 0 0 0 1 End bearing pile(i) factors	1 1 1 1 1 1 1 Friction and End bearing pile(i) factors

Appendix 2
Input files problem 1&2 as example

1- Interaction input file:

Load transfer approach	Elastic approach	Field measurements input factors
0	1	2
4	4	4
0.5	0.5	0.5
0.5	0.5	0.5
0.5	0.5	0.5
0.5	0.5	0.5
10 5	10 5	10 5
1	10 5	10 5
1	10 5	10 5
1	10 5	10 5
1	1	100000
1	1	100000
1	1	100000
1	1	100000
1	1	2 (must be 0 in problem 1)
1	1	(could be 1 or 2 in problem 2)
1	1	1 ← could be 1, 2 or 3
1	1	
1	1	
1	1	
1	1	
1	1	
1	1	
1	1	
1	1	
1	1	
1	1	
1	1	
1	1	
1	1	
1	1	
1	1	
1	1	
1	1	
1	1	
100000	1	
100000	1	
100000	1	
100000	100000	
0 (must be 0 in problem 1)	100000	
(could be 1 or 2 in problem 2)	100000	
1 ← could be 1, 2 or 3	100000	
	2 (must be 0 in problem 1)	
	(could be 1 or 2 in problem 2)	
	1 ← could be 1, 2 or 3	

2- Pile-pile factors file (α):

Read U_{ii} from this file	Load transfer approach	Elastic approach
1 0.002 0.002 0.002 0.002 1 0.25 0.5 0.25 0.25 1 0.25 0.5 0.5 0.25 1 0.25 0.25 0.5 0.25 1	2 1 0.25 0.5 0.25 0.25 1 0.25 0.5 0.5 0.25 1 0.25 0.25 0.5 0.25 1	3 1 0.25 0.5 0.25 0.25 1 0.25 0.5 0.5 0.25 1 0.25 0.25 0.5 0.25 1

3- Pile-soil factors file (β):

Read U_{ii} from this file	EHSPAK
1 0.0035 I =1 0.0033 I =2 0.0032 0.0035 . . . . . 0.0034 I=100 (EHS discritization 10×10) 1 I=1, J=1 0.25 I=1, J=2 0.5 I=1, J=3 0.25 . . . . 0.25 I=4, J=97 0.15 I=4, J=98 0.15 I=4, J=99 1 I=4, J=100	2 1 I=1, J=1 0.25 I=1, J=2 0.5 I=1, J=3 0.25 . . . . 0.25 I=4, J=97 0.15 I=4, J=98 0.15 I=4, J=99 1 I=4, J=100

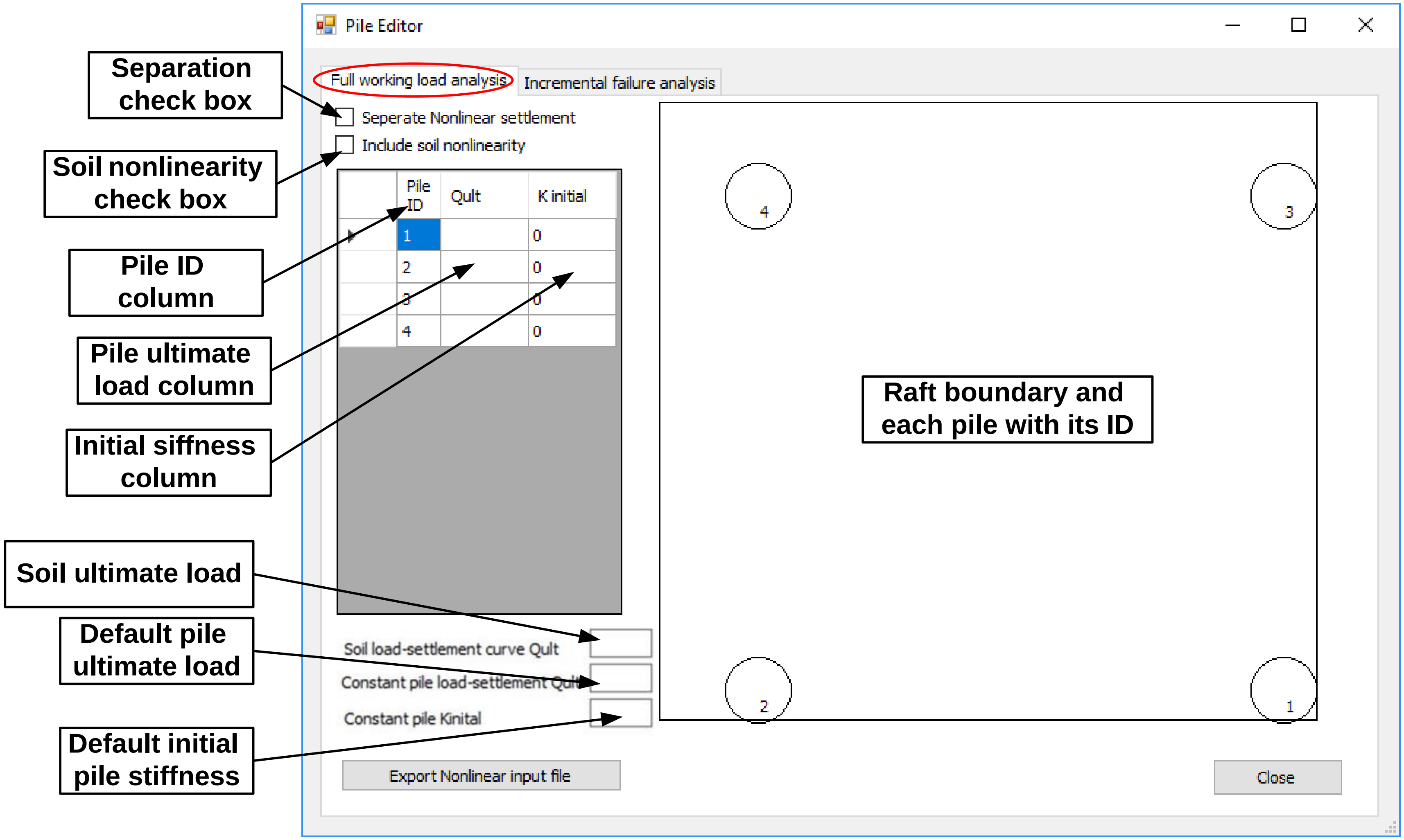
4- Soil properties file ($soil$):

Problem 1	Problem 2
2 Any no. Any no. Any no. Any no. 10 3000 0.3 30 5000 0.35 Any no. Any no.	2 17 12 10 10 10 3000 0.3 30 5000 0.35 10 10

Piles Editor Tool

This tool help the user to extract the nonlinear input file automatically to use it later in the NLPAK.

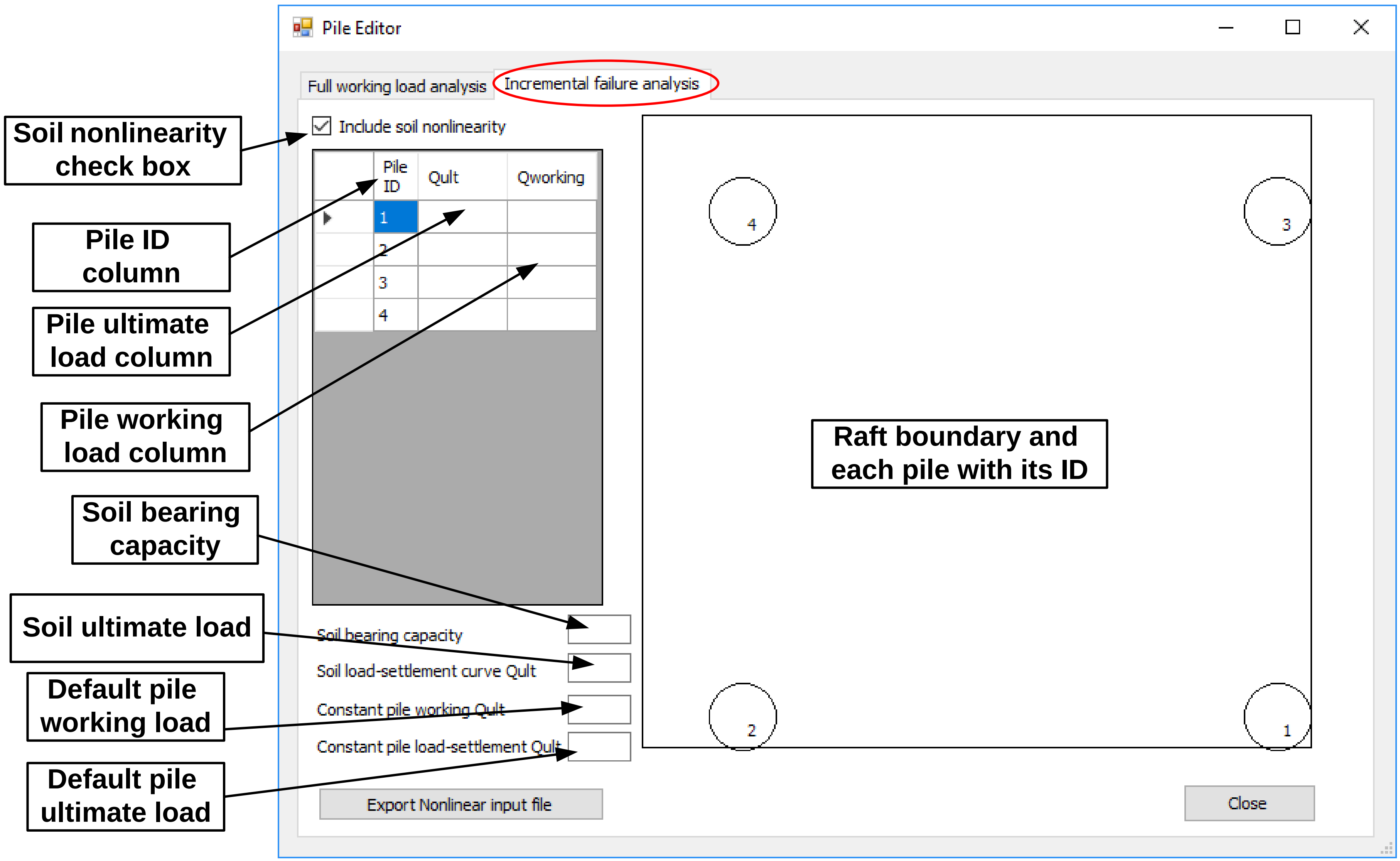
1- Full working load approach:



Item	Description
Separation check box	User should active this checkbox if separation process between interaction and nonlinear settlements is needed in the analysis.
Soil nonlinearity check box	User should active this checkbox if soil will be modeled as nonlinear half space.
Pile ID column	Column contains pile ID matched with the drawing (will be loaded automatically).
Pile ultimate load column	Column contains the ultimate load of each pile obtained from load-settlement curve (Q_{ult}).
Pile initial stiffness column	Column contains the initial stiffness of each pile obtained from load-settlement curve ($K_{initial}$).
Soil ultimate load	User should write the ultimate load of soil obtained from load-settlement curve (Q_{ult}).
Default pile ultimate load	The value written in this cell will written automatically in pile ultimate load column for all piles.
Default pile initial stiffness	The value written in this cell will written automatically in pile initial stiffness column for all piles.

After adjust the entire analysis variables just click on **Export Nonlinear input file** button.

2- Incremental failure analysis approach:



Item	Description
Soil nonlinearity check box	User should active this checkbox if soil will be modeled as nonlinear half space.
Pile ID column	Column contains pile ID matched with the drawing (will be loaded automatically).
Pile ultimate load column	Column contains the ultimate load of each pile obtained from load-settlement curve (Q_{ult}).
Pile working load column	Column contains the working load of each pile obtained from pile load test or design codes (the load that pile will be failed) ($Q_{working}$).
Soil bearing capacity	Soil bearing capacity value (In case of nonlinear soil only).
Soil ultimate load	User should write the ultimate load of soil obtained from load-settlement curve (Q_{ult}).
Default pile ultimate load	The value written in this cell will written automatically in pile ultimate load column for all piles.
Default pile working load	The value written in this cell will written automatically in pile working load column for all piles.

After adjust the entire analysis variables just click on **Export Nonlinear input file** button.