

The $PLPAK^{TM}$

The Pile-Pile/Soil interactions (P-PPAK) MANUAL

PLPAK[™] Version 2.00

The Advanced Single-Floor (Foundation) Package

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e-mail: <u>plpak@be4e.com</u> web: <u>https://www.plpak.com</u> The P-PPAK is an add-in tool to the PLPAK that allows simulation of pile-pile/soil interactions effects underneath piled rafts.

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

P-PPAK consider three types of interaction effects:

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.

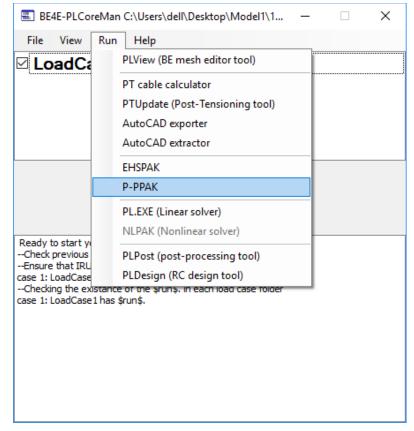
Problem 1:

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.

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			Run Select Edit Draw Segments Points Beams	
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		Slab:		
		Area: 100 m2 Material: Concrete		
		Distibuted Load: 0 t/m2		
		Thickness : 0.8 m		
	ľ –			

- 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).



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File name: C:\Users\dell\Desktop\Model1\1	I.LC		Open (.LC) F	ile
Interaction input file:			Browse	
Pile-Pile factors file:	Browse	Pile-Pile and Pile-Soil factors	do not work	
Pile-Soil factors file:	Browse	with Poulos nor Randolph	methods.	
Soil Properties file:			Browse	
Interaction Input and Solution	n log	Soil Properties log		
Piles Editor		Run P-P	Close	

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

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Interac	tion Input and Solution log		Soil Properties	s log		
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b. Load soil properties file (File format see appendix 1).

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BE4E - P-PPAK			- 🗆 ×
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Piles Editor		Run P-P	Close

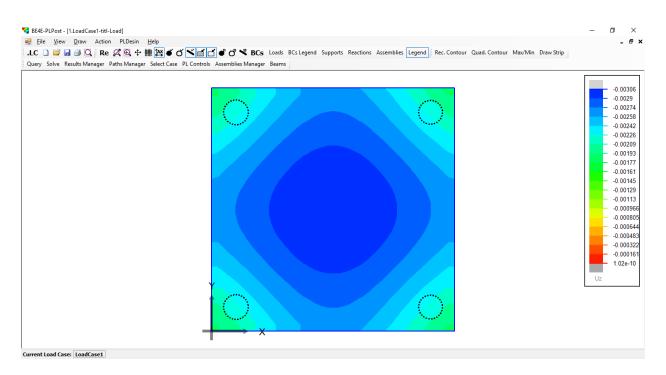
4- Close P-PPAK and go back to PLCoreMan.

5- Run PL.exe (Linear solver).

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		PTUpdate (Post-Tensioning tool)		
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		PL.EXE (Linear solver)		
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6- Show results on PLPost.

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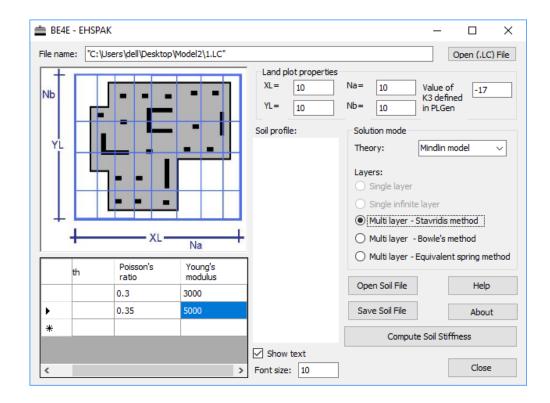
Problem 2: This problem is 10×10 m piled raft with thickness 0.8 m supported on four piles each 0.5 m radius and two-layered elastic half space subjected to its own weight.

1- Generate Gen model.

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	: ve vup. 🥃 🖌 Move Copy Array Match Wall Assembly	Slab: Area: 100 m2 Material: Concrete Distibuted Load 0 Um2	

- 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).

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)	File View	Run Help PLView (BE mesh editor tool)	 	
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٢		>	Show text Font size: 10	_			Close	

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

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File View	Run	Help			
✓ LoadCa		PLView (BE mesh editor tool)		 	
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		EHSPAK			
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Interaction input file:		Browse
Pile-Pile factors file:	Browse Pile-Pile and Pile-Soil factors do n	ot work
Pile-Soil factors file:	Browse with Poulos nor Randolph met	nods.
Soil Properties file:		Browse
Interaction Input and Solution log	Soil Properties log	
Piles Editor	Run P-P	Close

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

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File name: C:\Users\dell\Desktop\Model2\1.LC					Open (.LC)) File
Interaction input file:	C: \Users \dell \Desktop \Model2 \Inpu	t Factors			Browse	<u>.</u>
Pile-Pile factors file:	C:\Users\dell\Desktop\Model2\A	Browse	Pile-Pile and Pile-Soil fa	ctors do	not work	
Pile-Soil factors file:	C: \Users \dell \Desktop \Model2\B	Browse	with Poulos nor Ran	dolph m	ethods.	
Soil Properties file:					Browse	:
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	ength livision	Method 1 is				
Piles Editor			Run P-P		Close	

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

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	Pile-Soil factors file:	C:\Users\dell\Desktop\Model2\B	Browse with Poulos nor Randolph	methods.
	Soil Properties file:	C:\Users\dell\Desktop\Model2\\$Soil		Browse
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		ength division	Method 1 is used. C:\Users\dell\Desktop\Model2\\$Soil Number of soil layers=2 Level of each layer from surface is: Layer 1 Z= 10 Layer 2 Z= 30	
P	Piles Editor		Run P-P	Close
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	💼 BE4E - P-PPAK		-	- 🗆 X
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	Pile-Soil factors file:	C:\Users\dell\Desktop\Model2\Br	Browse with Poulos nor Randolp	h methods.
	Soil Properties file:	C: \Users\dell\Desktop\Model2\\$Soil		Browse
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	Piles Editor		Run P-P	Close

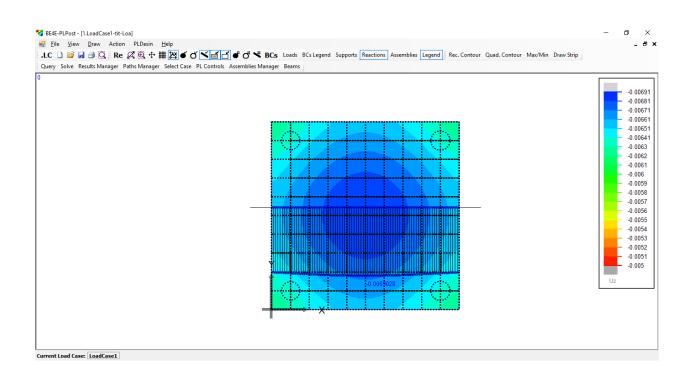
5- Close P-PPAK and go back to PLCoreMan.

6- Run PL.exe (Linear solver).

E BE4E-PLCo	reMar	n C:\Users\dell\Desktop\Model1\1	-	\times
File View	Run	Help PLView (BE mesh editor tool)		
		PT cable calculator PTUpdate (Post-Tensioning tool) AutoCAD exporter AutoCAD extractor		
		EHSPAK P-PPAK		
		PL.EXE (Linear solver)		
Ready to start y		NLPAK (Nonlinear solver)		
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7- Show results on PLPost.

BE4E-PLCoreMan C:\Users\dell\Desktop\Model1\1					
File	View	Run	Help		
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			AutoCAD exporter		
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	ition is fin		is completed		
			update the solution status		
Check previous solutions via the .STT files					
case no.1: LoadCase1 previously solved successfully Ensure that IRUNFlags in all .RUN files are 1					
	LoadCase				~



<u>Appendix 1</u> <u>Input files Structure</u>

input mes 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
. \rightarrow Radius for each pile.
•
· · ·
\mathbf{r}_{Np}
L2,d2
Length and number of divisions for each pile.
$\langle Note: Load transfer approach method, piles have the same length and same divisions. \rangle$
i.e. this part will be only one line in this case (L, d).
L_{Np}, d_{Np}
- F ₁
\mathbf{F}_2
. 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.)
$\mathbf{F}_{\mathbf{m}}$
$-\mathbf{E}_{\mathbf{p}1}$
E_{p2}
Young's modulus for each pile.
E _{pNp}
- 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. <u>Pile-pile factors file (α):</u>

- $1/2/3$ 1: U _{ii} read from this file, 2: U _{ii} calculated from load transfer approach, 3: U _{ii} calculated
from elastic approach.
- U1
U ₂
U_{ii} for each pile. (Exist only in case of U_{ii} read from this file" i.e. the first line is 1").
O_{11} for each price (Exist only in case of O_{11} read from this file (i.e. the first file is 1).
•
U_{Np}
- α ₁₁
α ₁₂
. $[\alpha]_{Np*Np}$ pile-pile interaction factors matrix as % from U _{ii} written as a one column.
•
•
$\alpha_{(Np*Np)}$

1.2. <u>Pile-soil factors file (β):</u>

- $1/2$ 1: U _{ii} read from this file, 2: U _{ii} calculated from EHSPAK.
- U ₁
U ₂
U_{ii} for each soil cell. (Exist only in case of U_{ii} read from this file "i.e. the first line is 1").
U_{Np}
- β 11
β12
[β] Np*Nhs pile-soil interaction factors matrix as % from U _{ii} written as a one column
$(row_1, row_2, \dots, row_{Np})$. (Note: N _{hs} is the total number of half space soil cells.)
$\beta_{(Np*Nhs)}$

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

- Nlayers, Idum, Idum Total number of soil layers, Any two dummy integer numbers.				
-Idum, Idum Any two dummy integer numbers.				
$-H_L, E_s, v_s$				
HL, Es, vs				
H _L ,E _s , v _s Layer soil modulus, Layer's poison's ratio, Layer depth from soil top surface.				
H_{L}, E_{s}, v_{s}				

Friction or End bearing factors

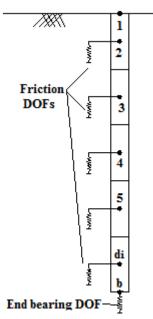


Figure A: Pile (i) friction and end bearing DOFs.

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

<u>Appendix 2</u> <u>Input files problem 1&2 as example</u>

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
10 5		0.5 10 5
10 5		10 5
1		10 5
1		10 5
1		100000
1		100000
1		100000
1		100000
1	1	2 (must be 0 in problem 1)
1	1	(could be 1 or 2 in problem 2)
1	1	1 \leftarrow 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	
100000 100000	1	
100000	1	
100000	100000	
0 (must be 0 in problem 1)	100000	
(could be 1 or 2 in problem 2)	100000	
$1 \leftarrow \text{could be } 1, 2 \text{ or } 3$	100000	
	2 (must be 0 in problem 1)	
	(could be 1 or 2 in problem 2)	
	1 \leftarrow could be 1, 2 or 3	

Read U _{ii} from this file	Load transfer approach	Elastic approach
1	2	3
0.002	1	1
0.002	0.25	0.25
0.002	0.5	0.5
0.002	0.25	0.25
1	0.25	0.25
0.25	1	1
0.5	0.25	0.25
0.25	0.5	0.5
0.25	0.5	0.5
1	0.25	0.25
0.25	1	1
0.5	0.25	0.25
0.5	0.25	0.25
0.25	0.5	0.5
1	0.25	0.25
0.25	1	1
0.25		
0.5		
0.25		
$\frac{1}{2 - p^2} + \frac{1}{2 - p^2$		

2- Pile-pile factors file (α):

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	EHSPAK 2 1 I=1, J=1 0.25 I=1, J=2 0.5 I=1, J=3 0.25
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.	2 17 12
Any no. Any no.	10 10
10 3000 0.3	10 3000 0.3
30 5000 0.35	30 5000 0.35
Any no. Any no.	10 10

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