BE4E – PLPAK

Towards more realistic structural modeling

Elastic Half Space Package (EHSPAK)

Table of content for lecture 5

- Elastic Half Space Package (EHSPAK)
  - Soil modeling introduction.
  - Single layer models.
  - Two parameter models.
  - Elastic Half Space models.
  - Multi-layer analysis using Elastic Half Space.
  - How can the user make a model using EHSPAK?
  - What are the differences between Winkler & EHS models?
  - Practical example.

Soil Modeling introduction

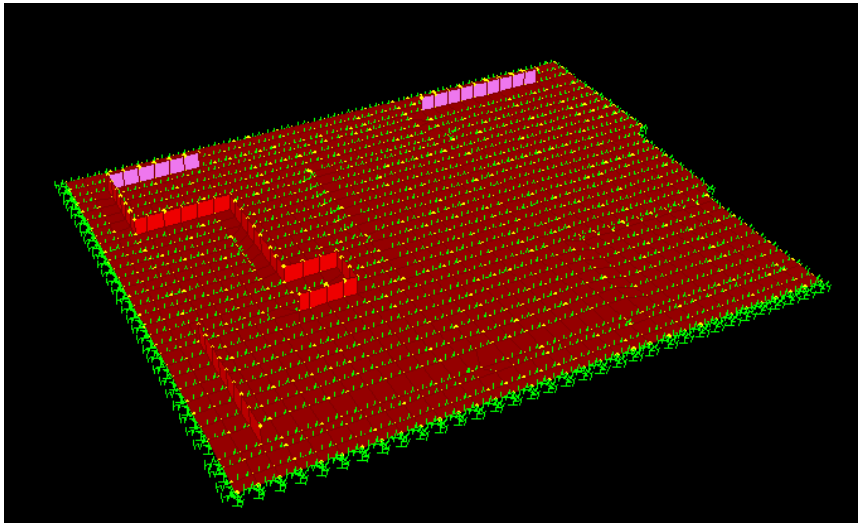
- Soil Models
  - Single layer model
    - Single Parameter model — As Winkler models
    - Two Parameters model — As Pasternak & Hetenyi models
    - Elastic model — As Elastic Half Space.
  - Multi-layer model — Solving as elastic model As Elastic Half Space.

Single layer model

The most common soil model is Winkler model.

• The Winkler model is very suitable to be coupled with finite element models, as it is based on converting the soil media into discrete springs that can be added directly at the finite element nodes.

• There are two disadvantages for the Winkler models:
- The Winkler model assumes that displacement occurs only at loaded springs and that the load has no effect on distant spring.
- The other disadvantage is that Winkler model accuracy is greatly dependant on the value of the spring constant utilized and this value is normally retrieved from empirical data that has very wide ranges.



Two Parameter models

To improve the disadvantages of one parameter models, the two parameter models are created to model the soil support.

• The two parameter models include the shear modulus effect of the soil (Pasternak) or membrane effect (Hetenyi).

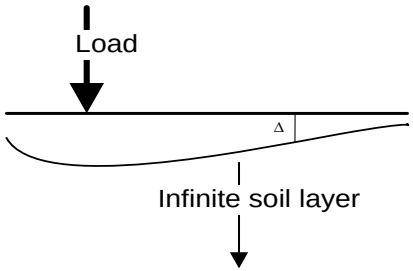
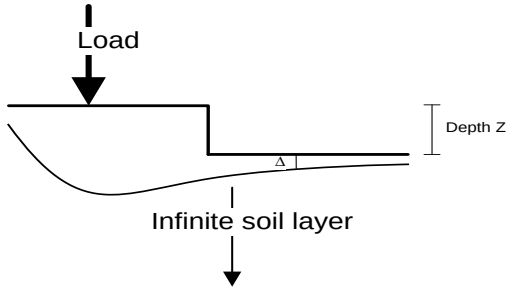
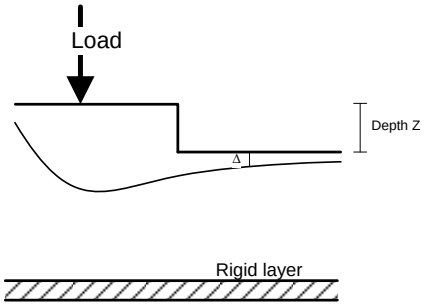
• The two parameter models have two problems:
- The mathematical complexity.
- The spring constants calculated are dependant on foundation shapes and applied loads.

To improve this methodology the ACI recommend to use the Elastic Half Space method. This method models considered the soil as three-dimensional elastic medium.

• To achieve the elastic properties of the soil there are three assumption should be taken into consideration:
- Soil has linear properties.
- Soil has elastic properties.
- No pore water present.

Elastic Half Space models

In the elastic half space there are three different elasticity solutions: Boussinesq, Mendlin, Steinbrenner.

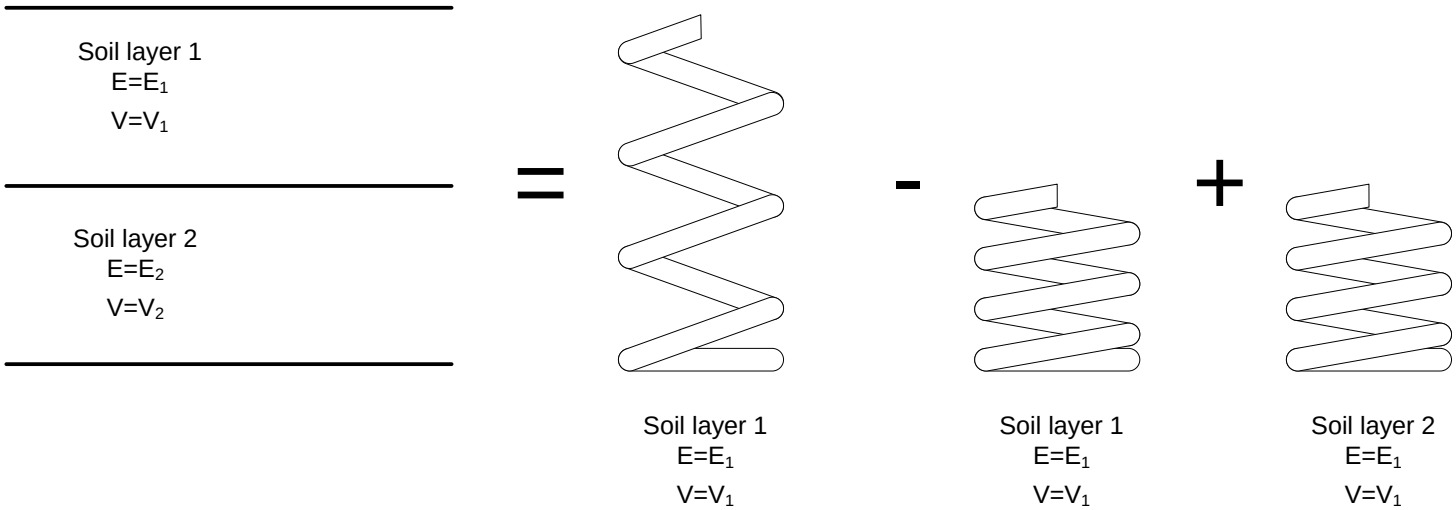
EHS model	schematic	Displacement calculated at different depths	Infinite soil layer/ support on layer
Boussinesq		No	Infinite soil layer
Mindlin		Yes	Infinite soil layer
Steinbrenner		Yes	Support on rigid base

Multi layer analysis using Elastic Half Space

In practical applications, it is very rare to find soil medium with a layer thick enough to consider it as alone as the supporting element.

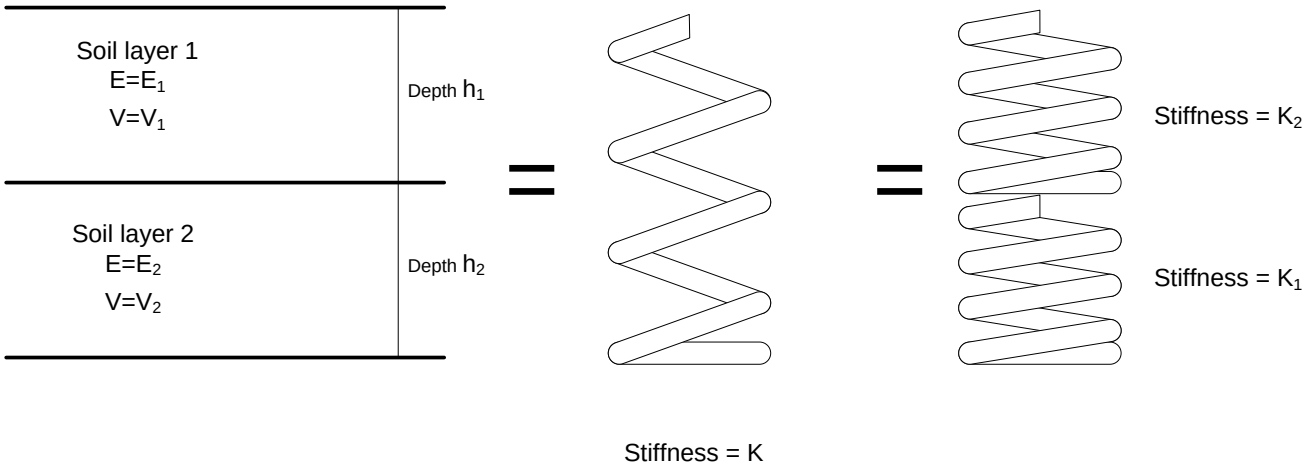
There are three different methodologies for calculating the stiffness of multi layer soil:

1- Staviridis method:



This method adopts a superposition scheme to calculate the equivalent soil stiffness

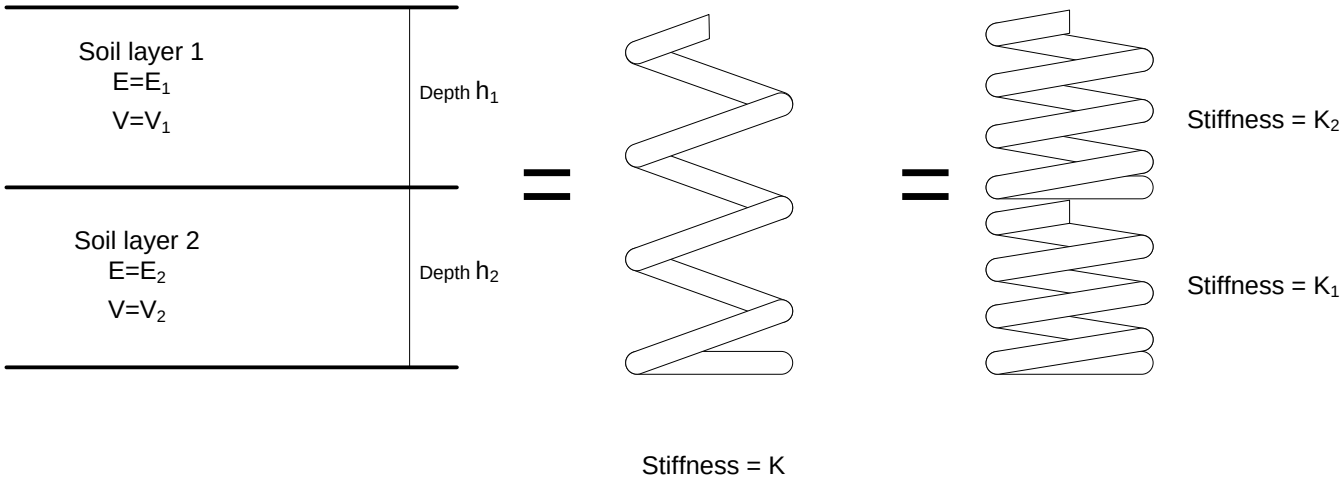
2- Bowles' method:



$$K = \frac{h_1 \times K_1 + h_2 \times K_2}{h_1 + h_2}$$

This method calculate the equivalent soil stiffness using the weighted average method.

3- Equivalent spring method:

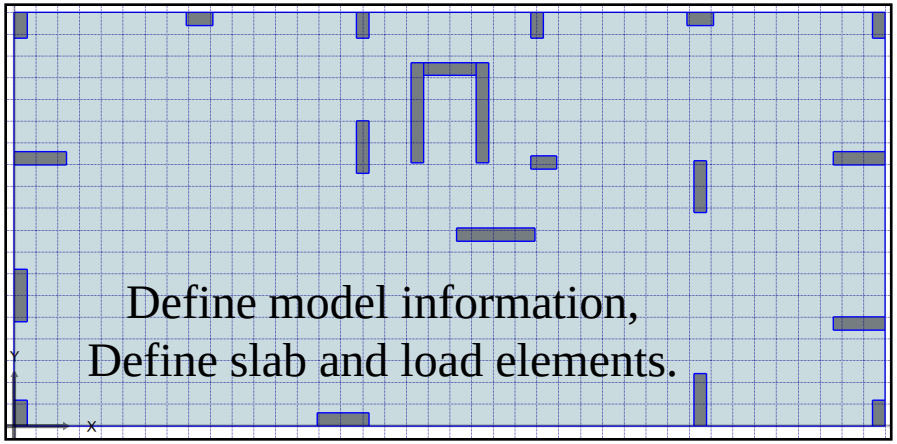


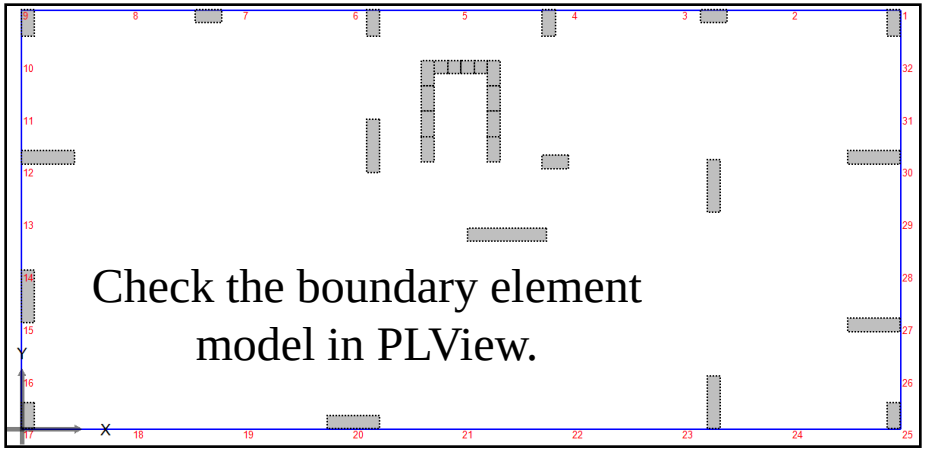
$$K = \frac{h_1 \times K_1 + h_2 \times K_2}{h_1 + h_2}$$

This method is simply calculate the equivalent soil spring by modeling the layers as springs connected in series .

How can the user make a model in EHSPAK?

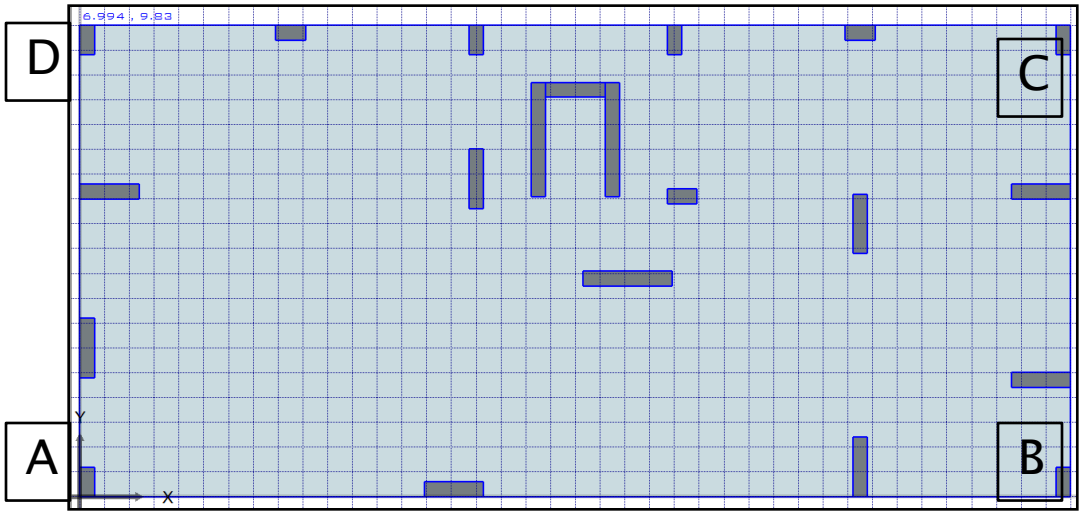
The same steps of Winkler model until the user draw the soil support.



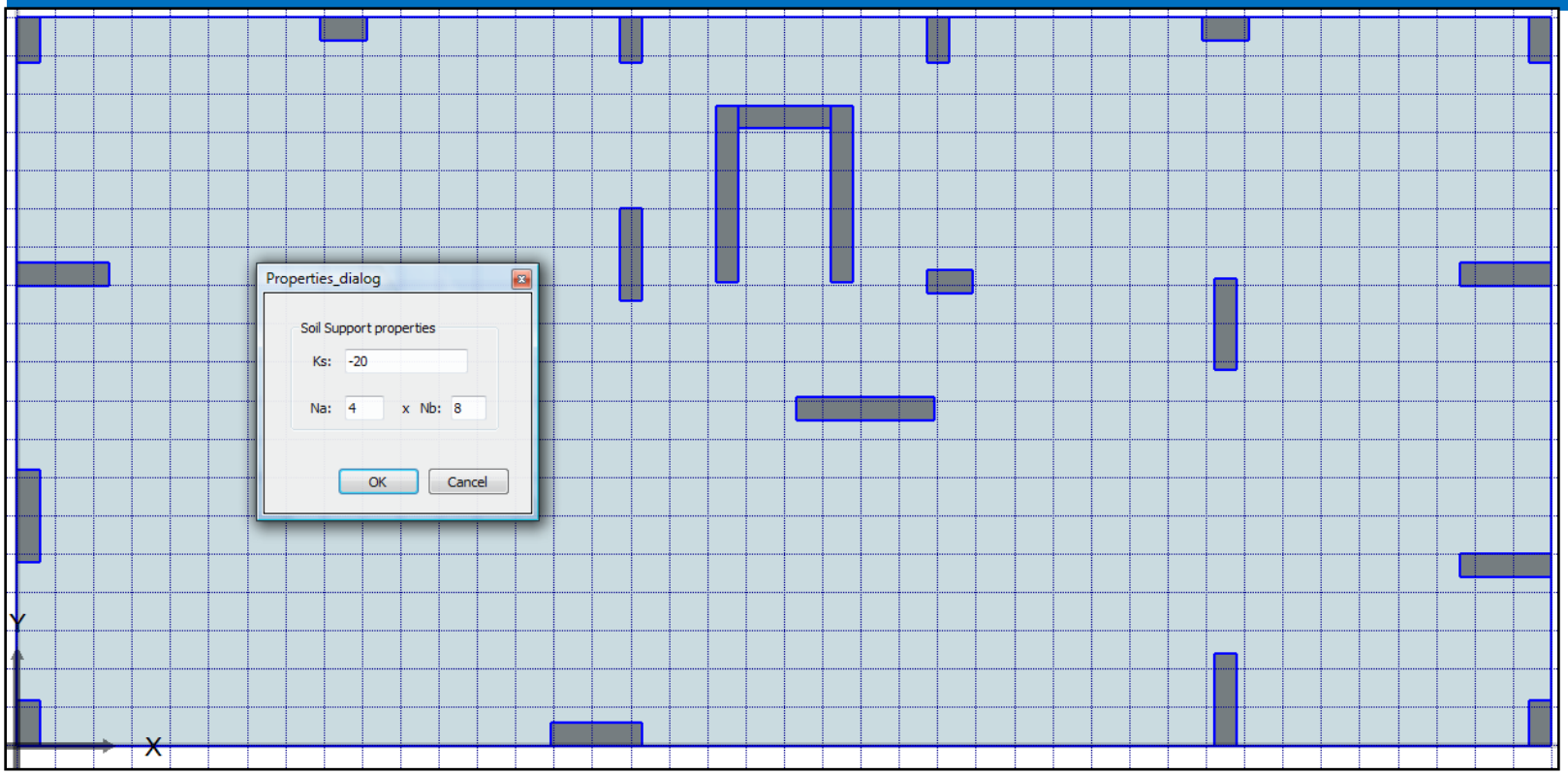


Draw rectangular soil support

From point A ⇨ B ⇨ C ⇨ D



How can the user make a model in EHSPAK?

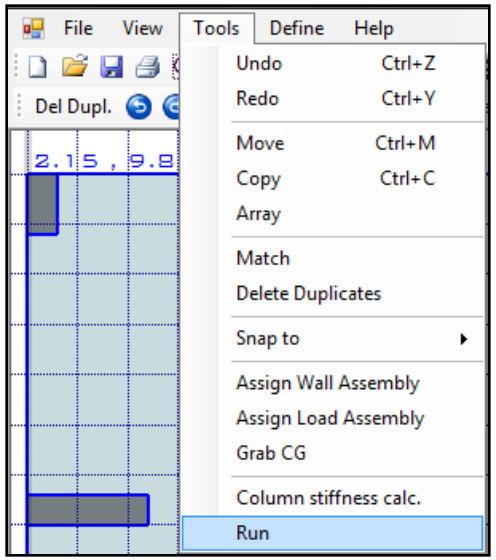


Change the soil stiffness to any –ve value, this value should be greater than 5 times slab thickness.

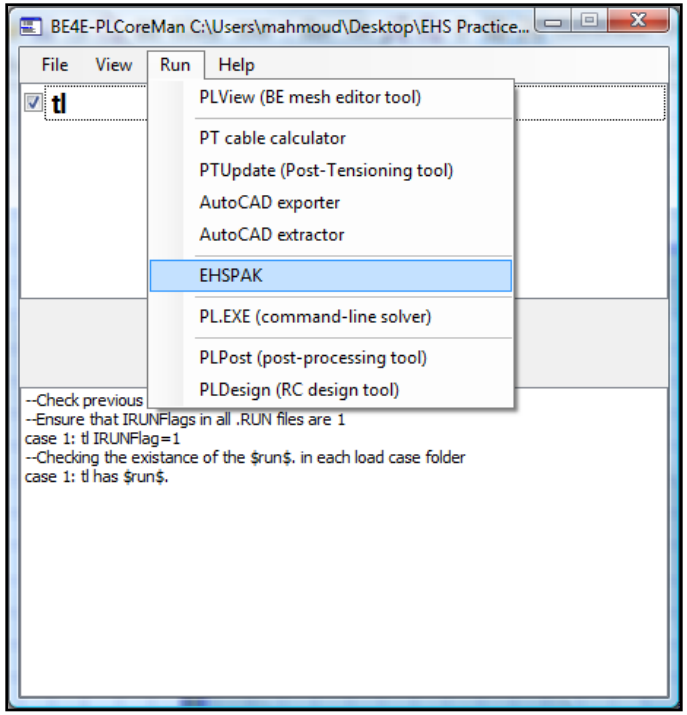
Check soil division before going to core manager (PLCoreMan).

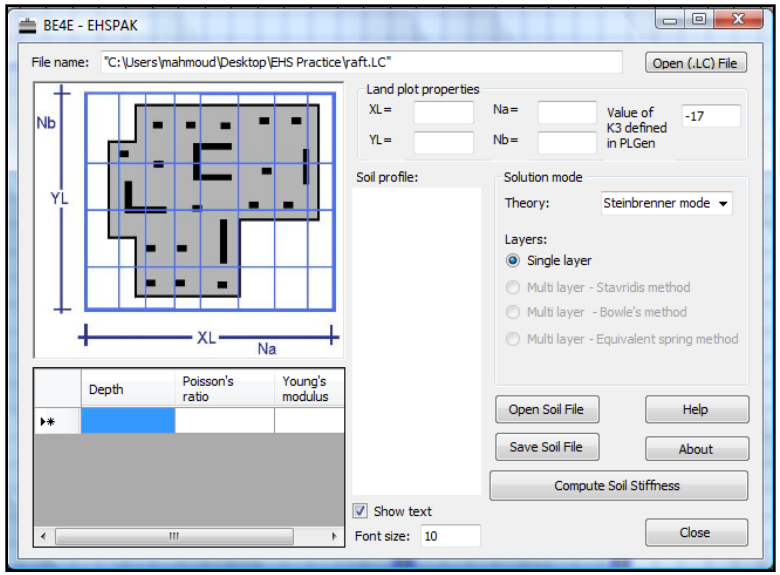
How can the user make a model in EHSPAK?

Open the PLCoreMan by pressing on run tab.



OR



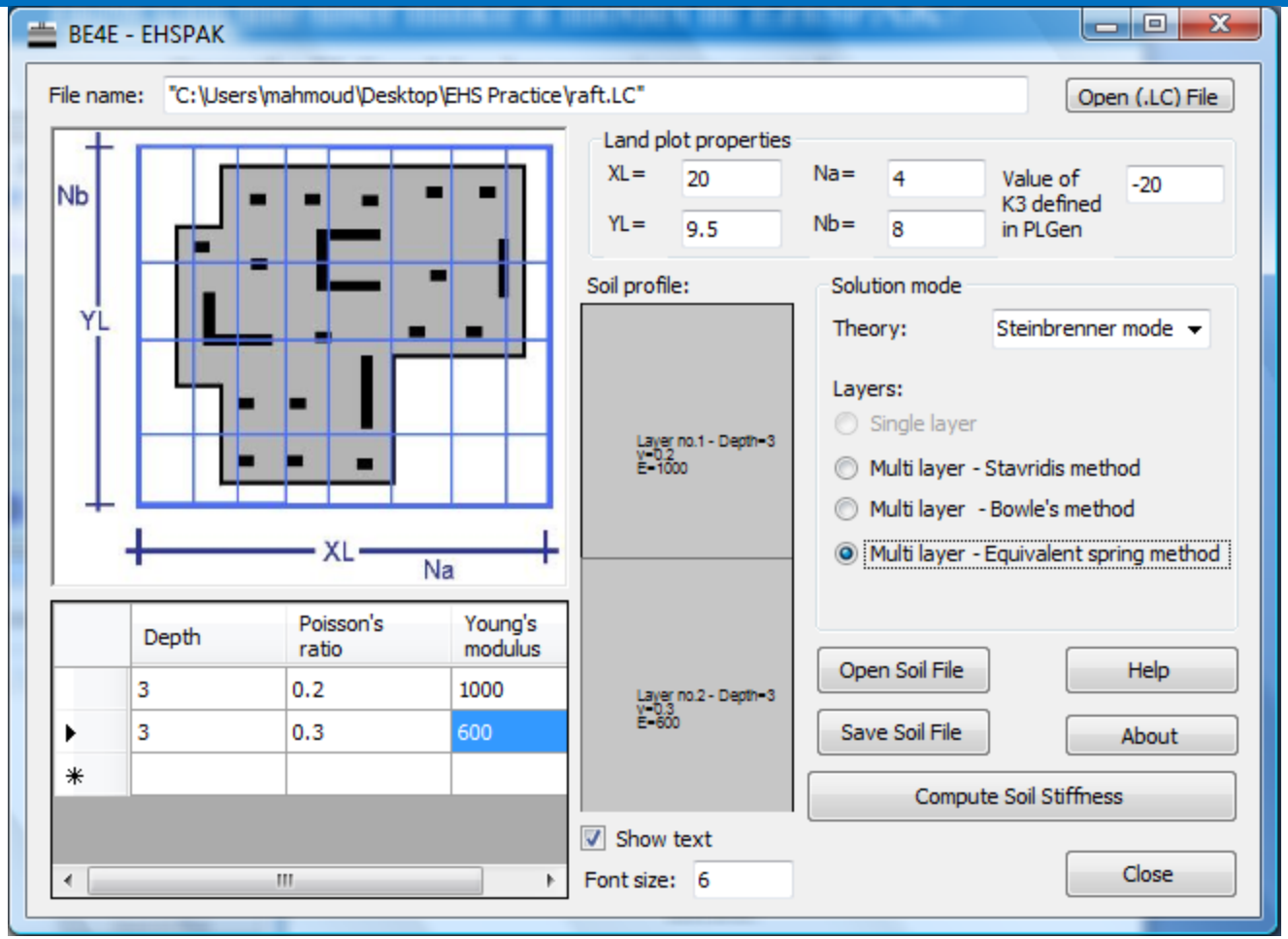


From the PLCoreMan, open the EHSPAK from run menu.

How can the user make a model in EHSPAK?

The user should insert the dimension of the rectangular raft and insert the number of division in both X & Y-directions.

There is an important note: the value of K3 should as same as the value defined in the PLGen.

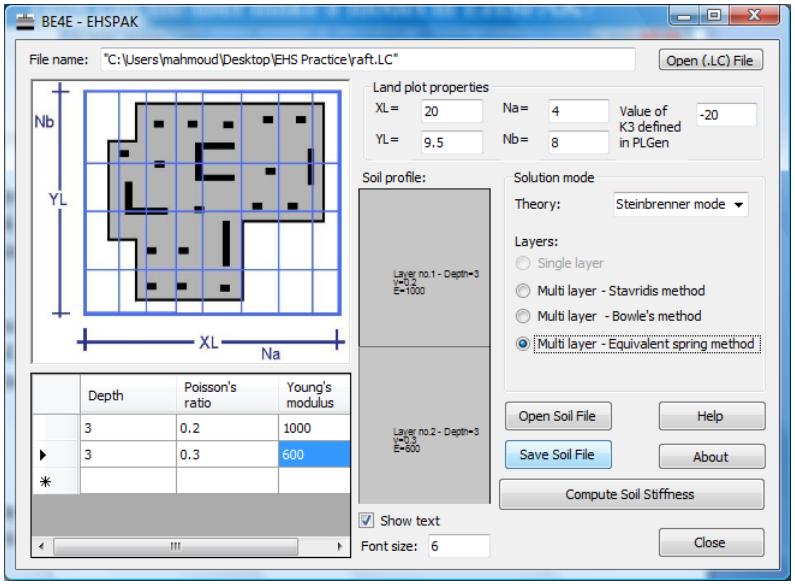


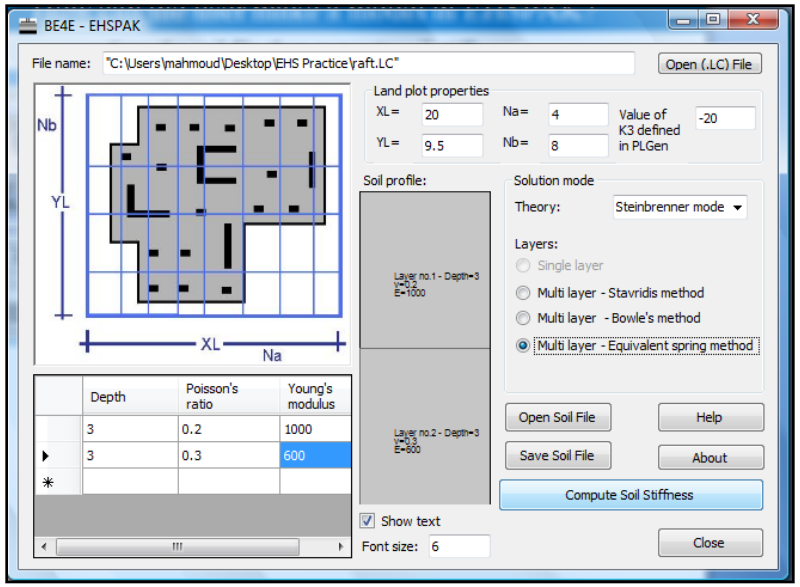
The user should insert the soil properties in EHSPAK

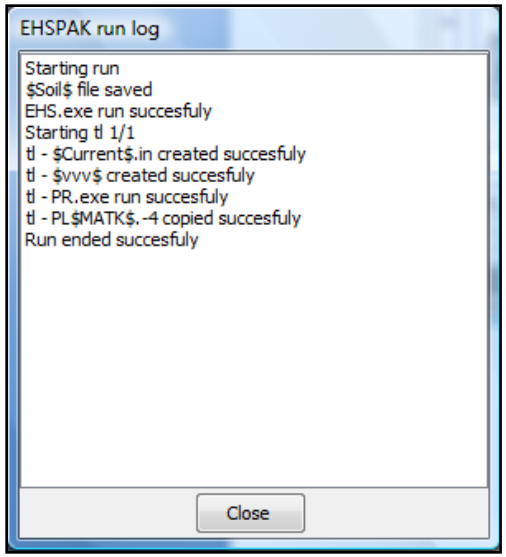
Choose the type of solution mode theory and layers.

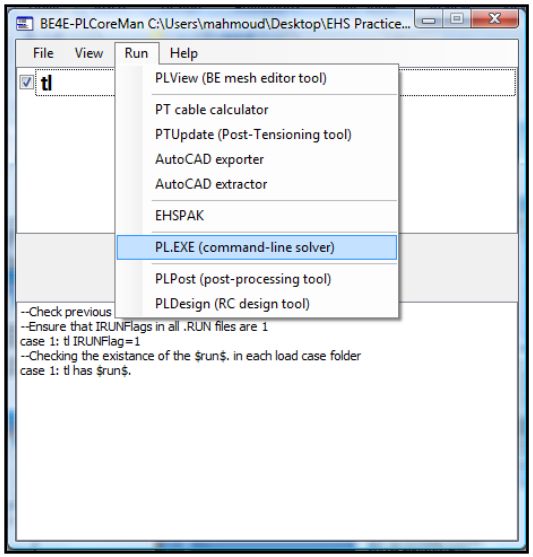
How can the user make a model in EHSPAK?

Save the soil file then compute soil stiffness.





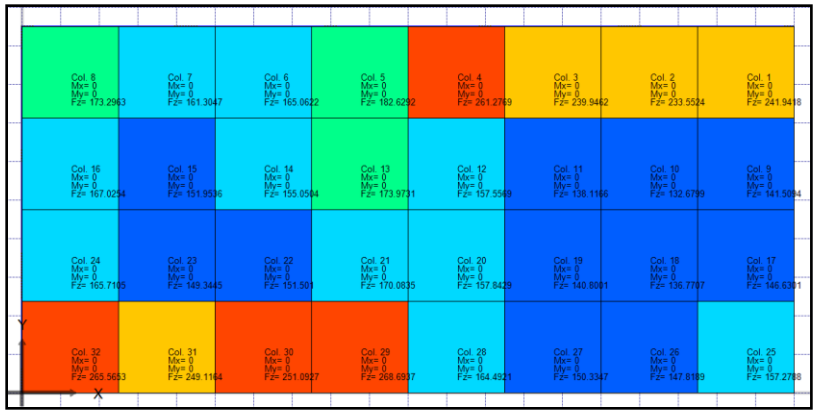




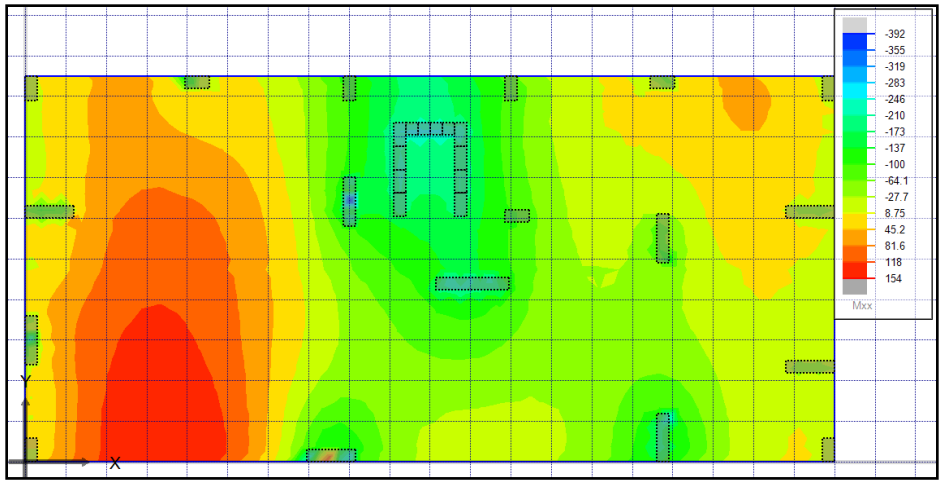
After running EHSPAK, open the PLCoreMan then run the model.

How can the user make a model in EHSPAK?

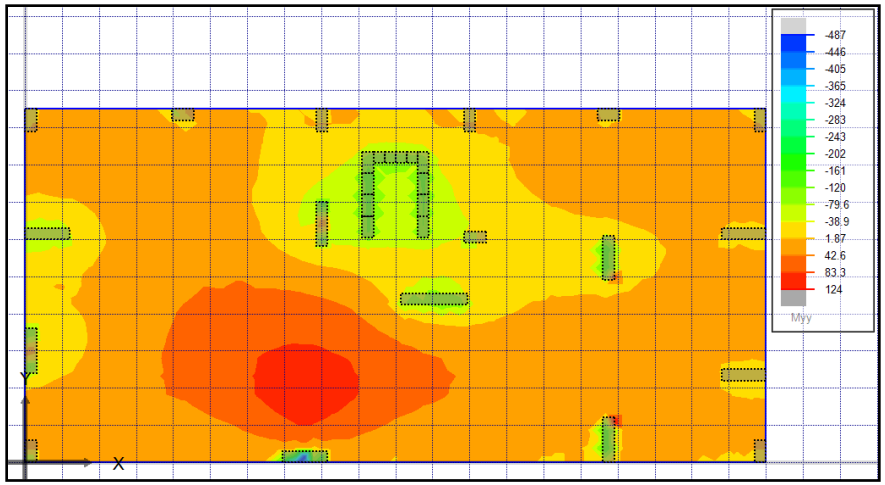
Open the PLPost to view the results.



Show the soil reaction.

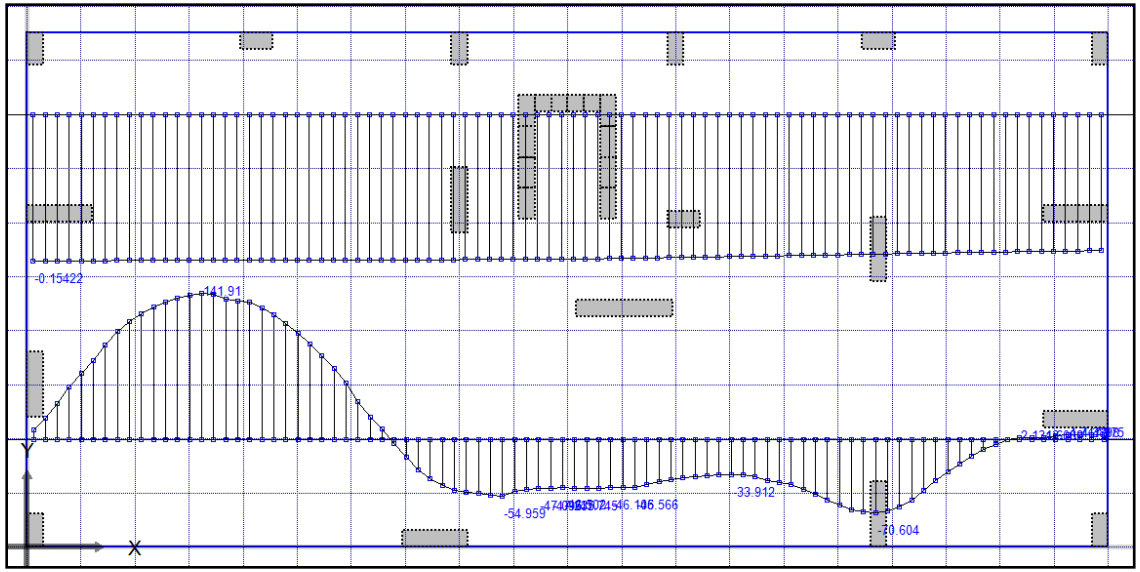


Moment in X-direction

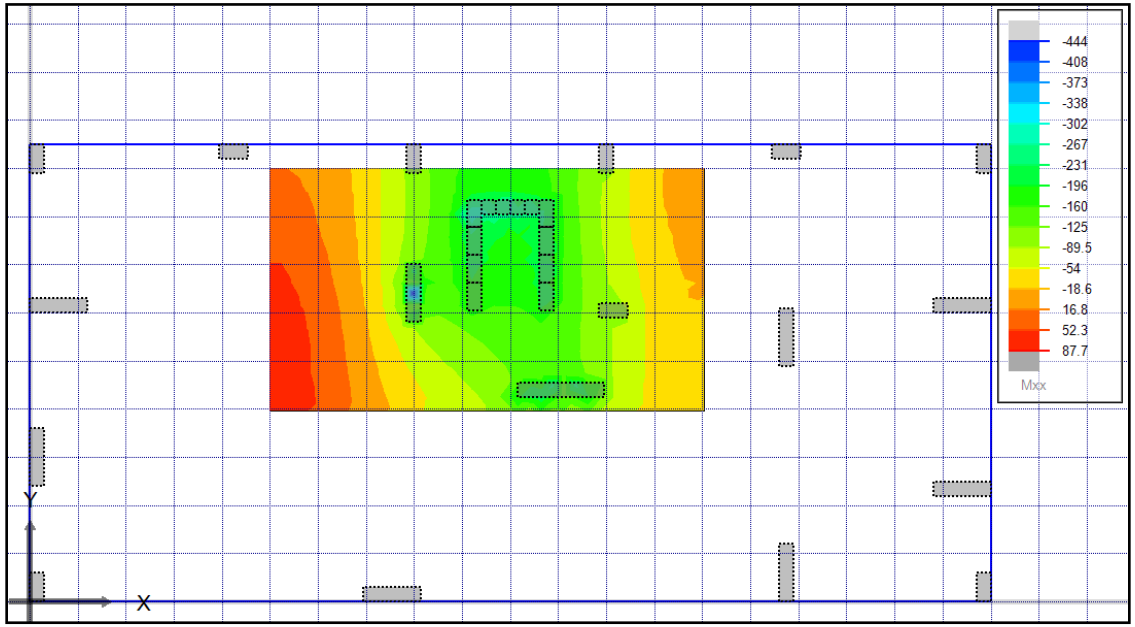


Moment in Y-direction

How can the user make a model in EHSPAK?



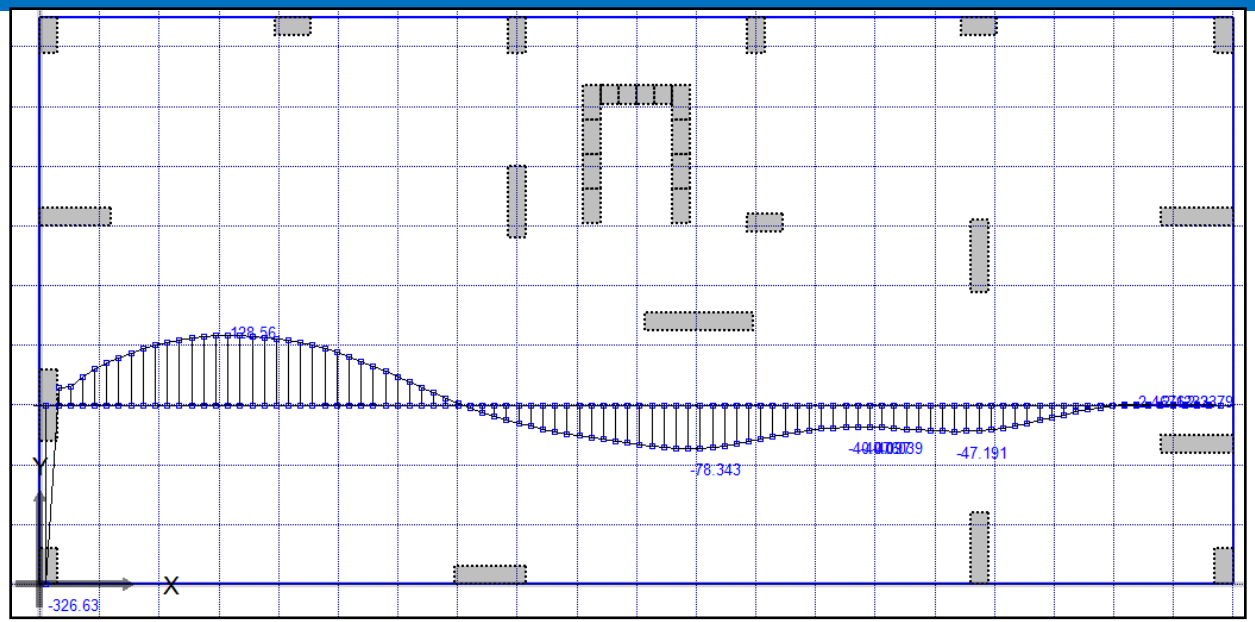
Strip analysis.



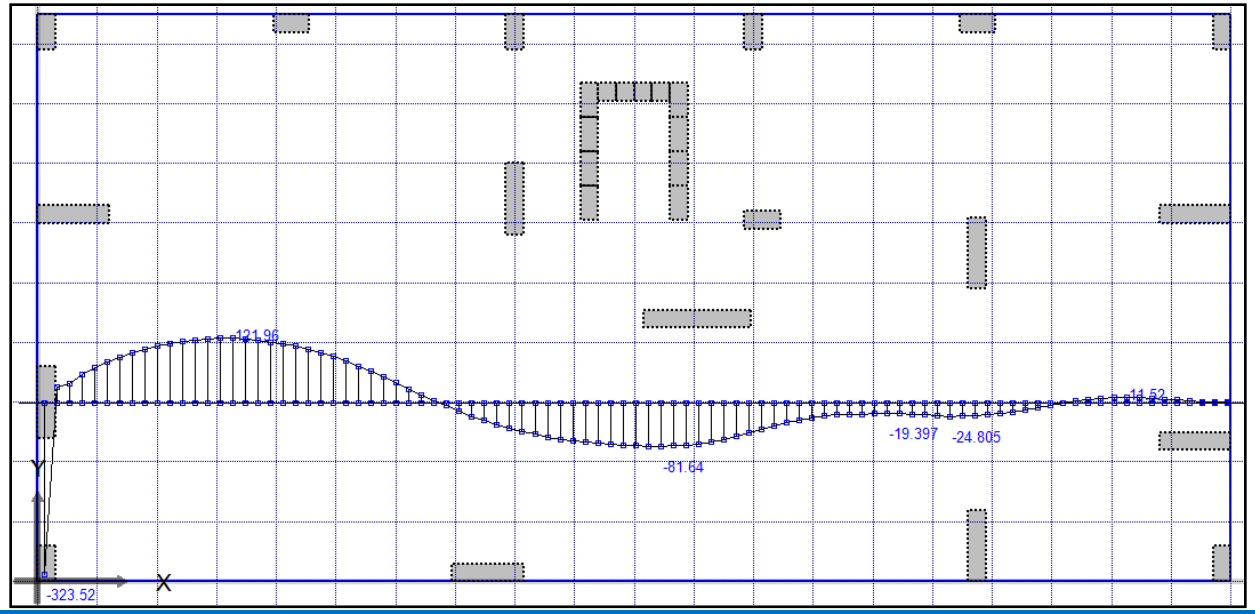
Rectangular contour.

What are the differences between Winkler & EHS models?

EHS model (moment in X-direction)

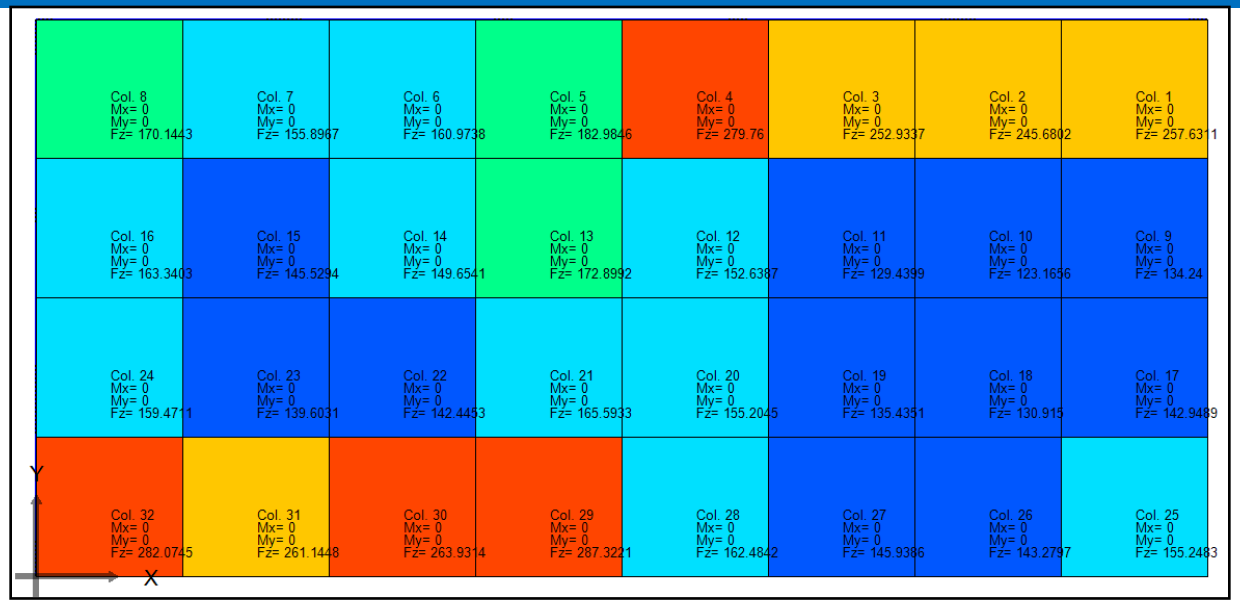


Winkler model (moment in X-direction).

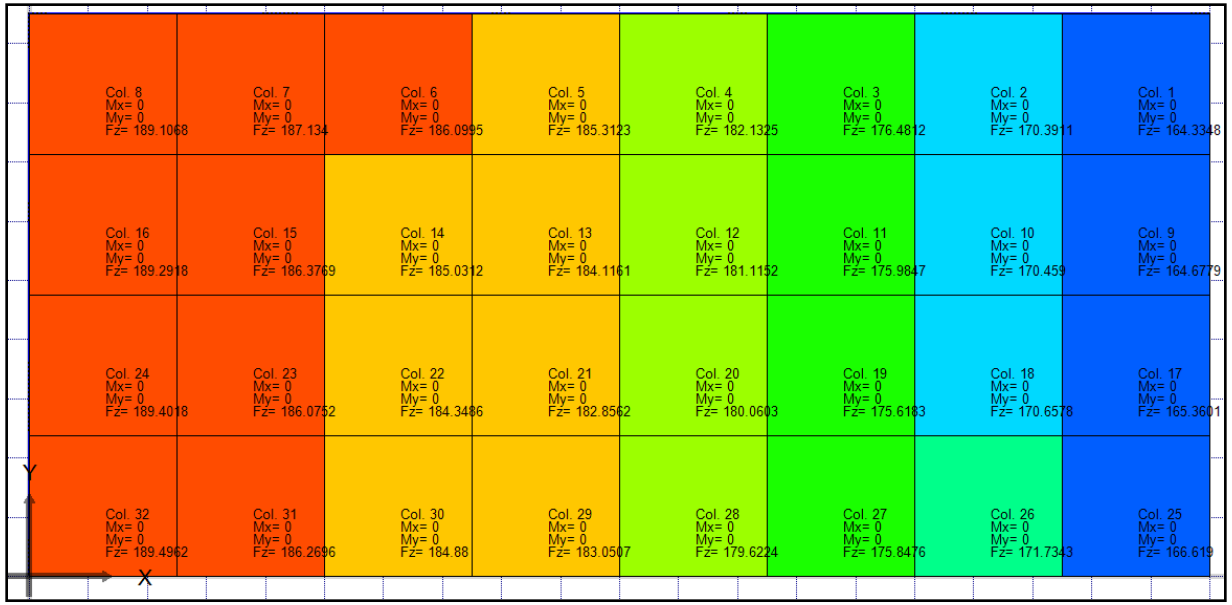


What are the differences between Winkler & EHS models?

EHS model (soil support reactions)

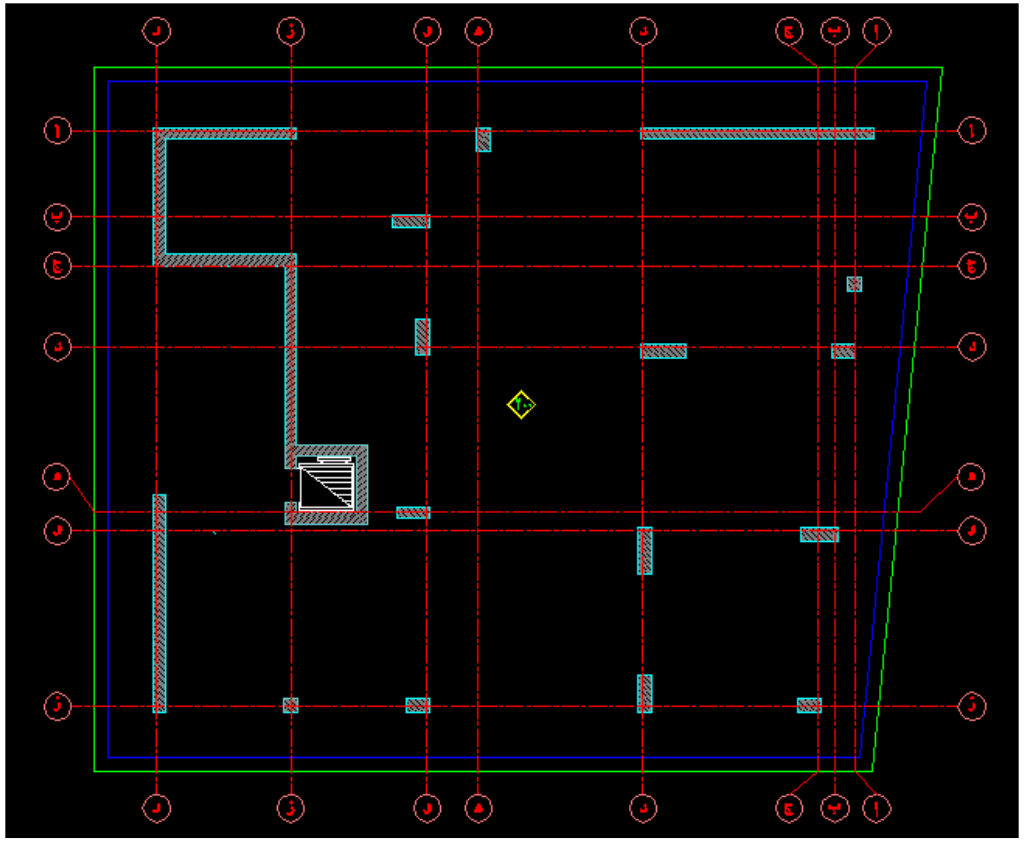


Winkler model (soil support reactions).

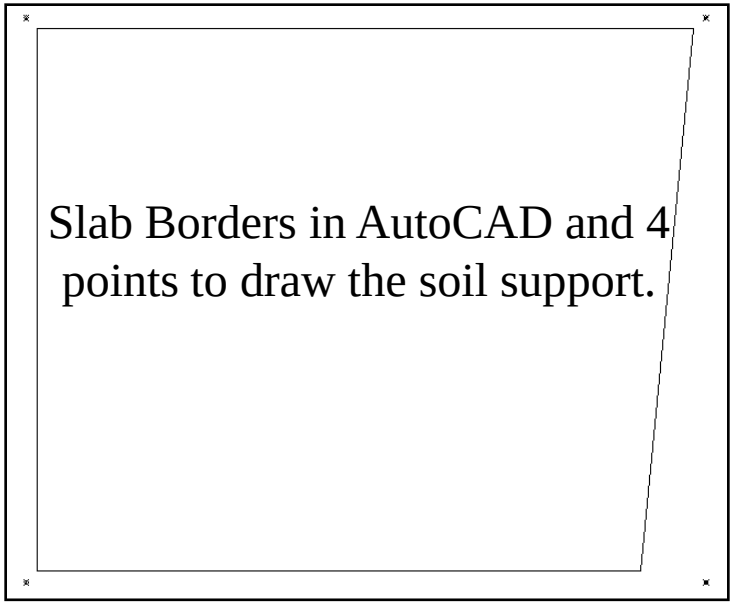


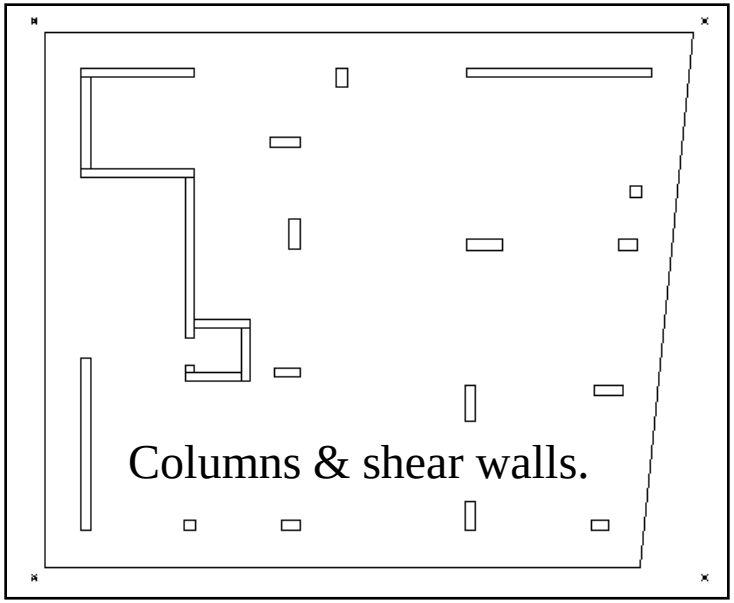
Practical Example

In this practical example we are going to learn how can we use elastic half space model in non-rectangular raft.

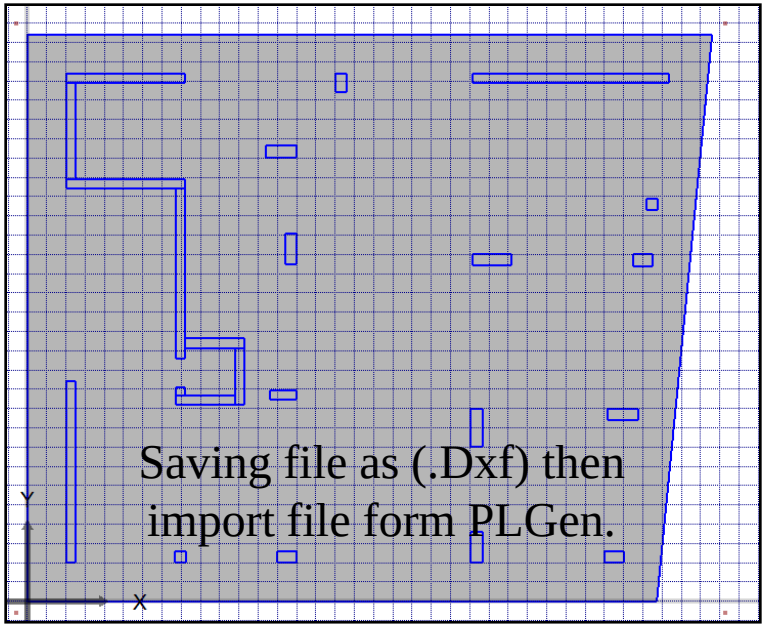


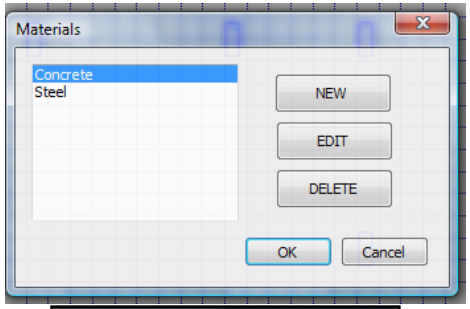
Practical Example

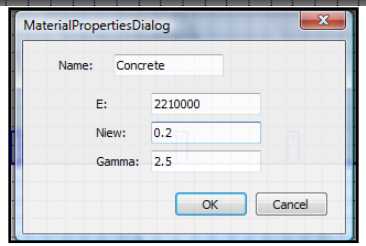


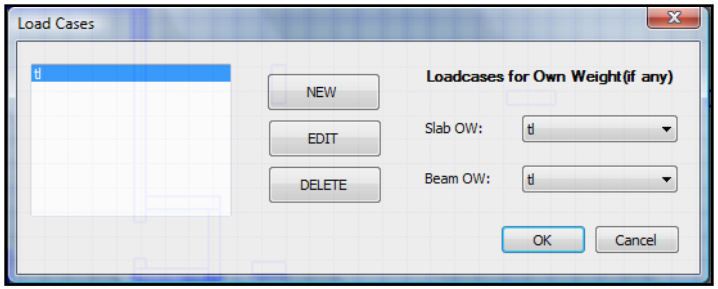


Practical Example

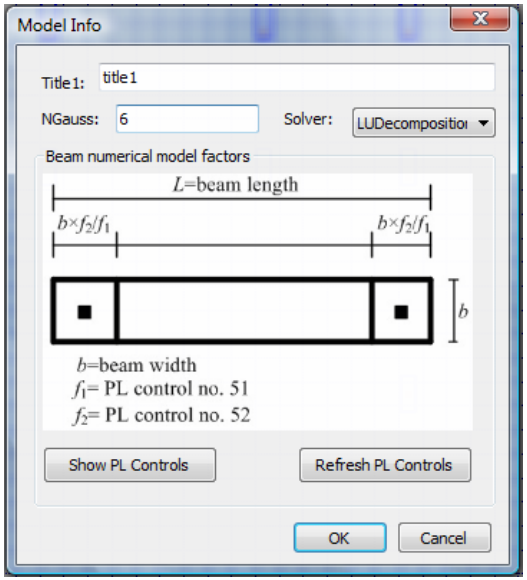






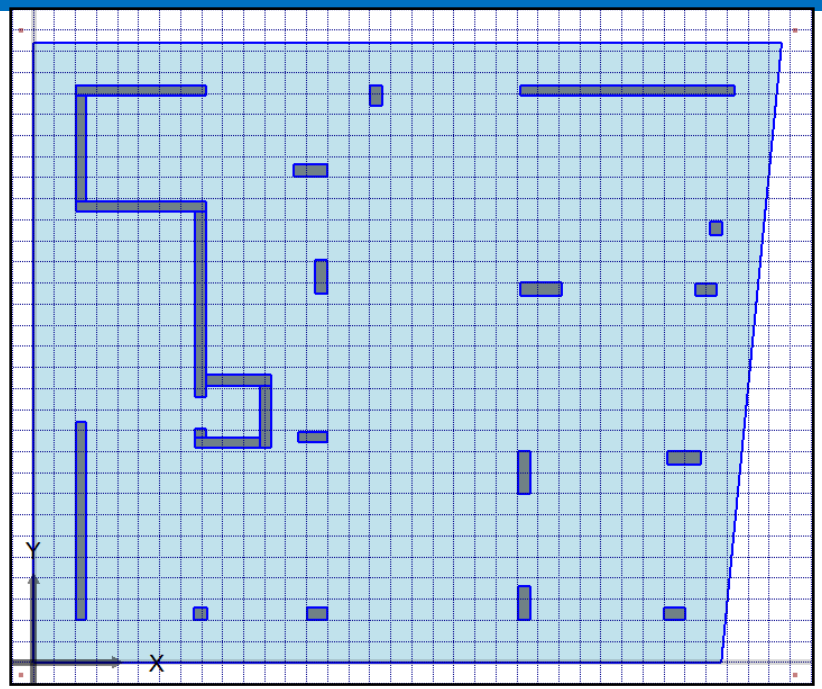


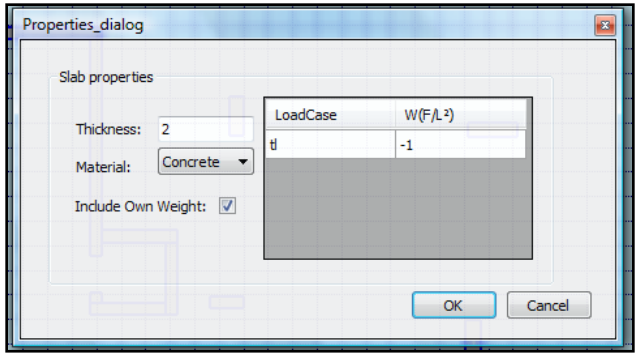
Adjusting Material properties, Load cases & Model information.



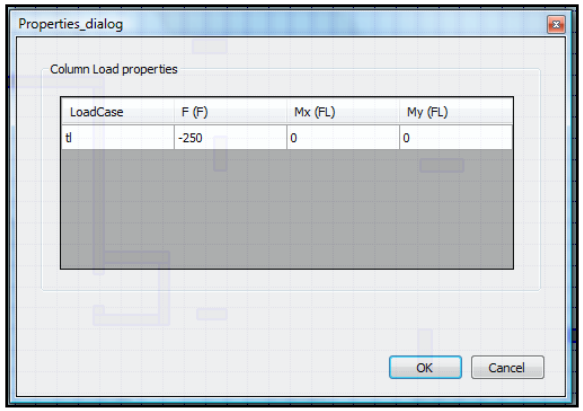
Practical Example

Define the slab, then Define the column and shear wall loads.

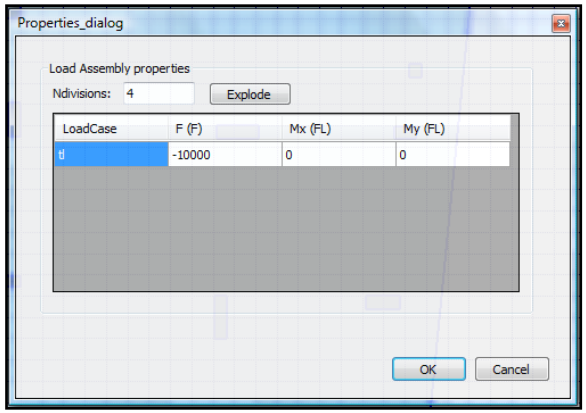




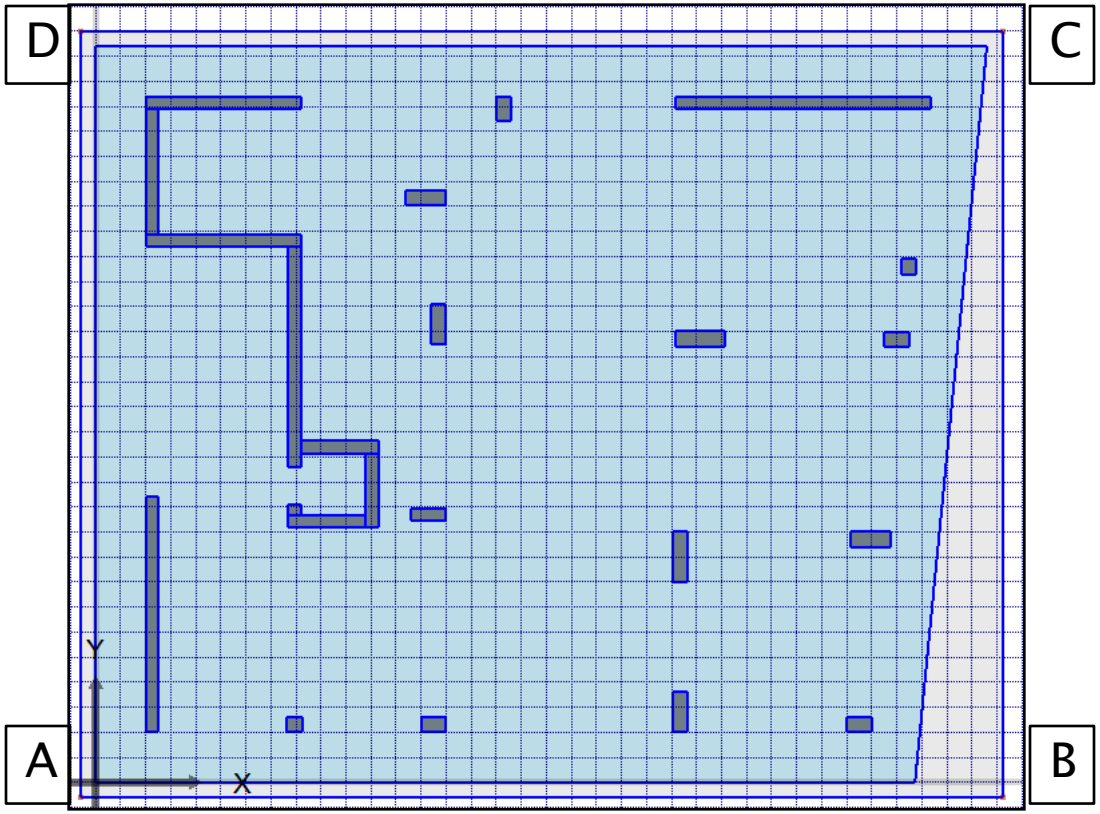
Define Slab Properties



Define Column loads

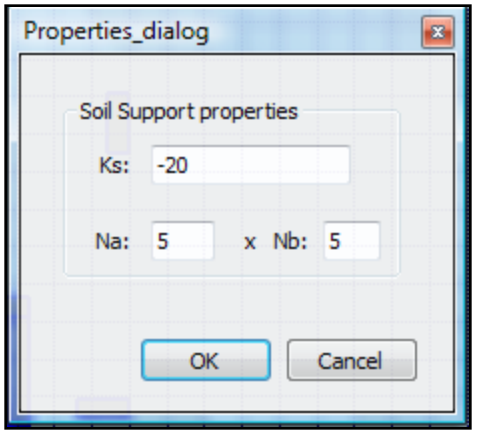


Define Wall loads



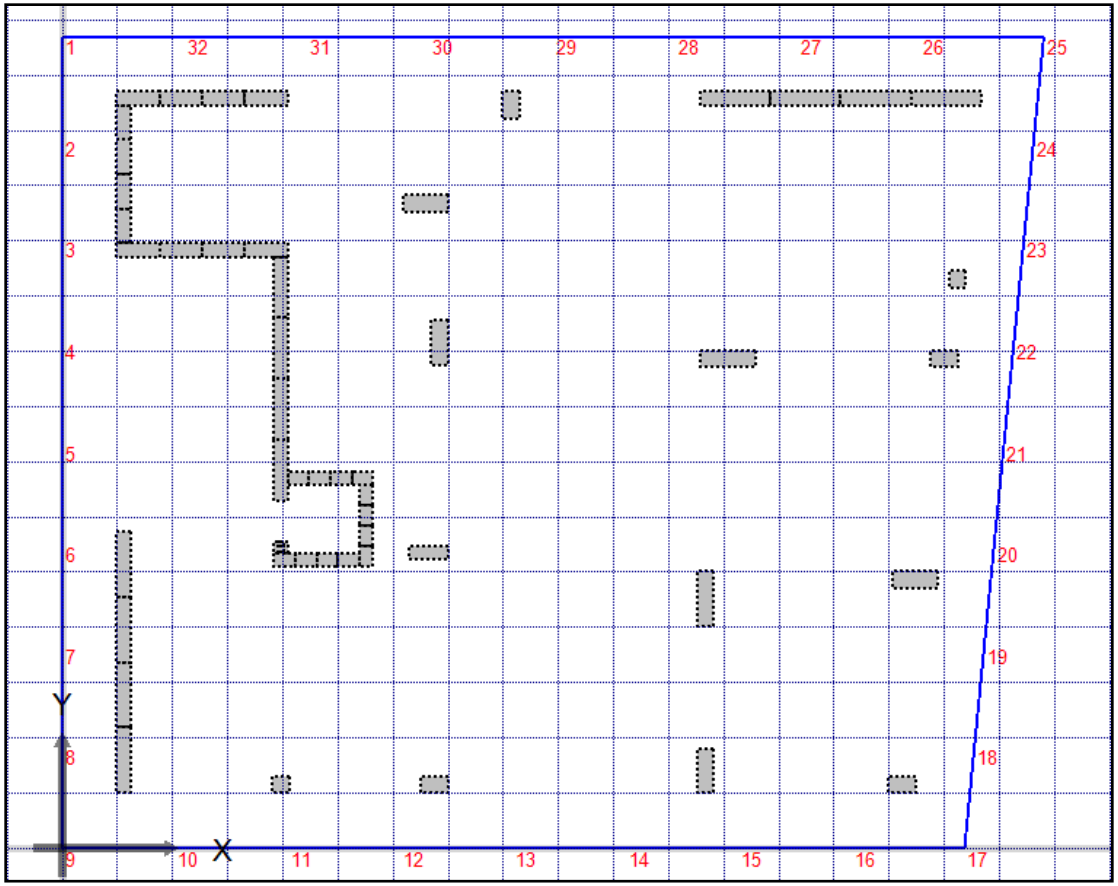
Draw Soil support from point

A ⟶ B ⟶ C ⟶ D



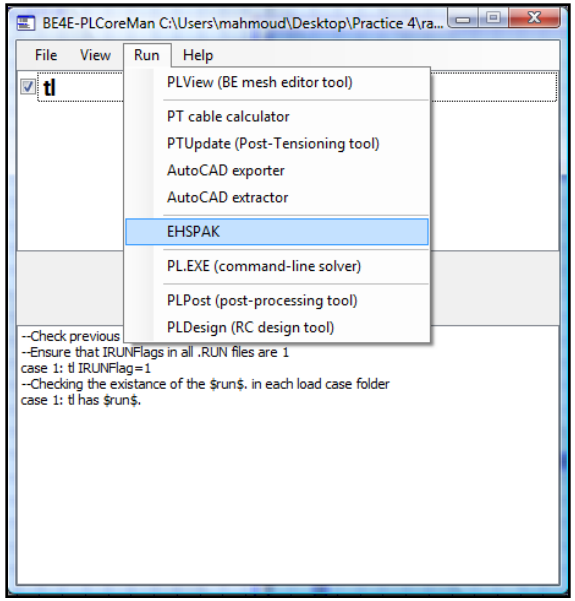
Soil support properties

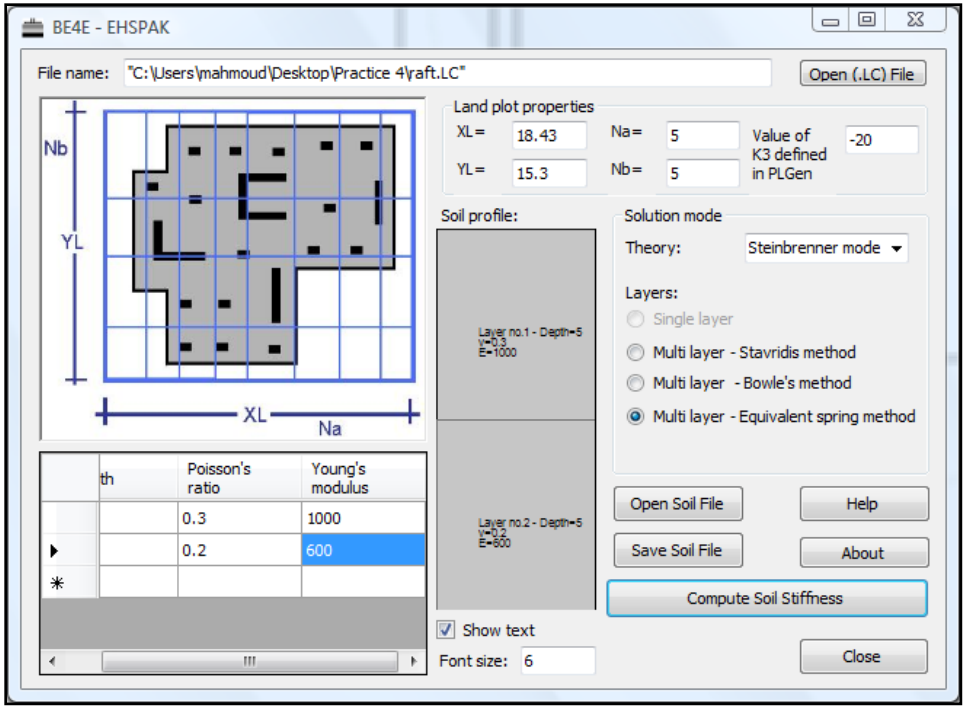
Practical Example

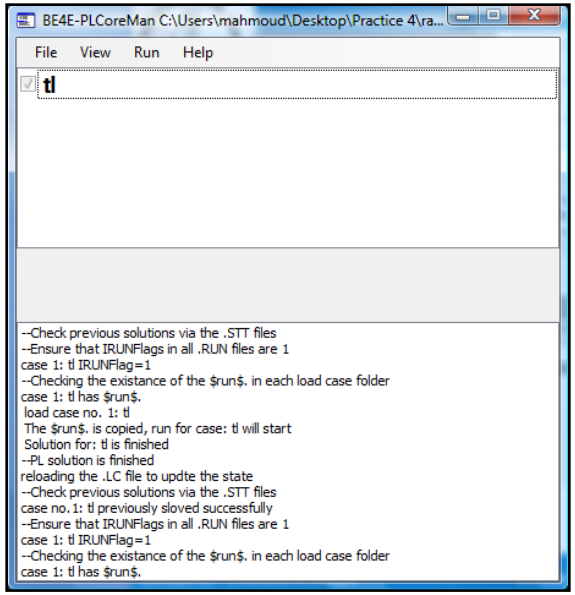


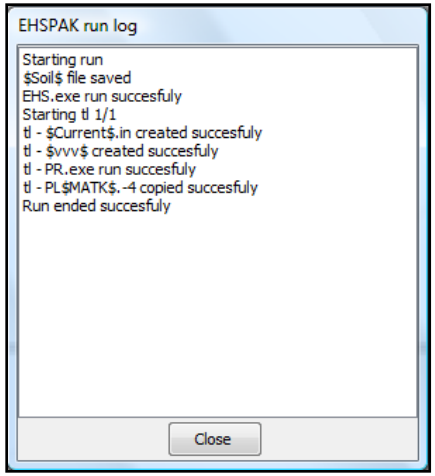
Check boundary element model
from PLView.

Practical Example





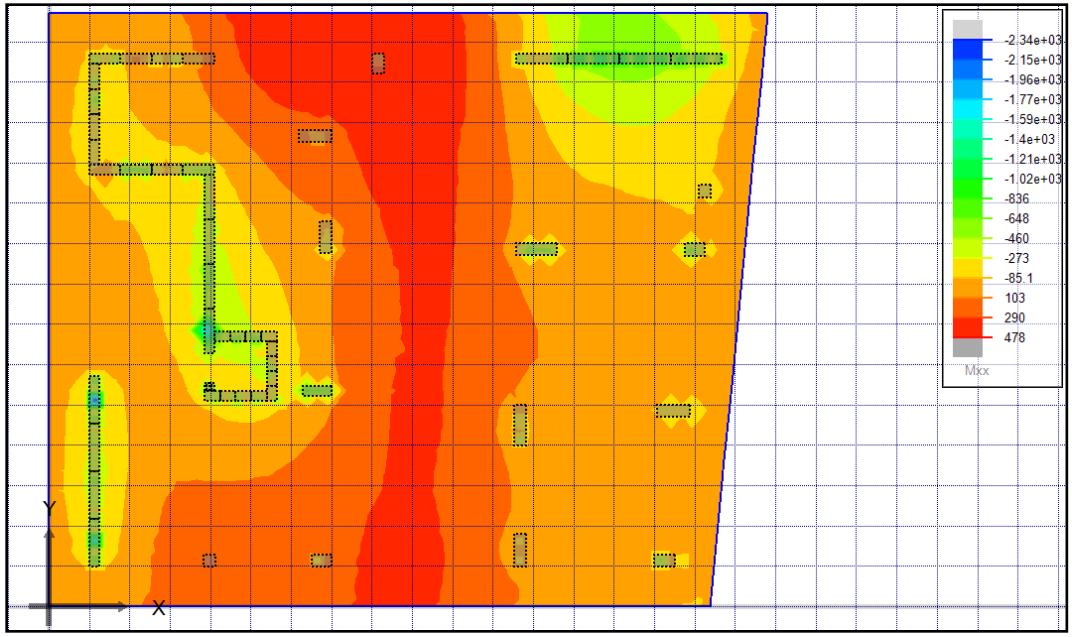




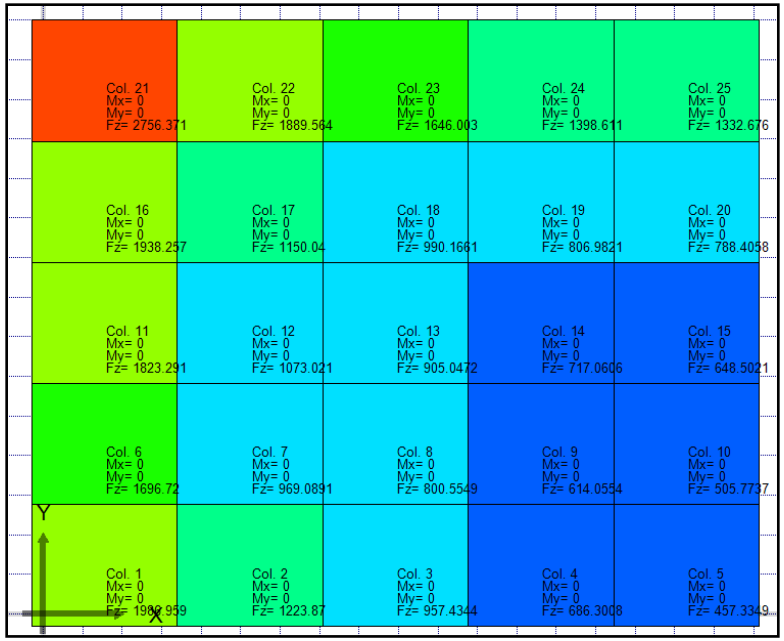
Form run tab open the PLCoreMan, then from run menu open EHSPAK.

Practical Example

Open the PLPost to show the straining actions.

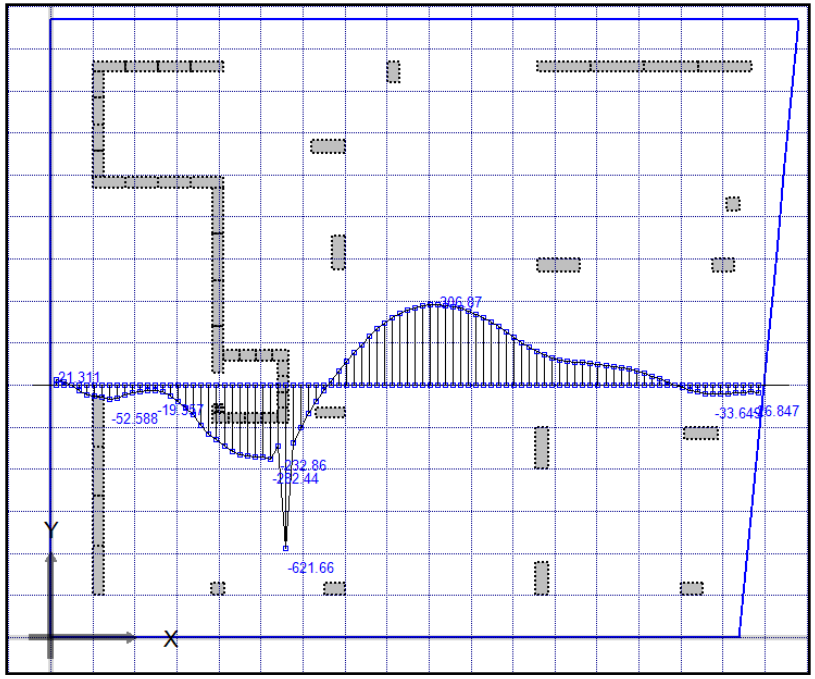


Moment in X-direction

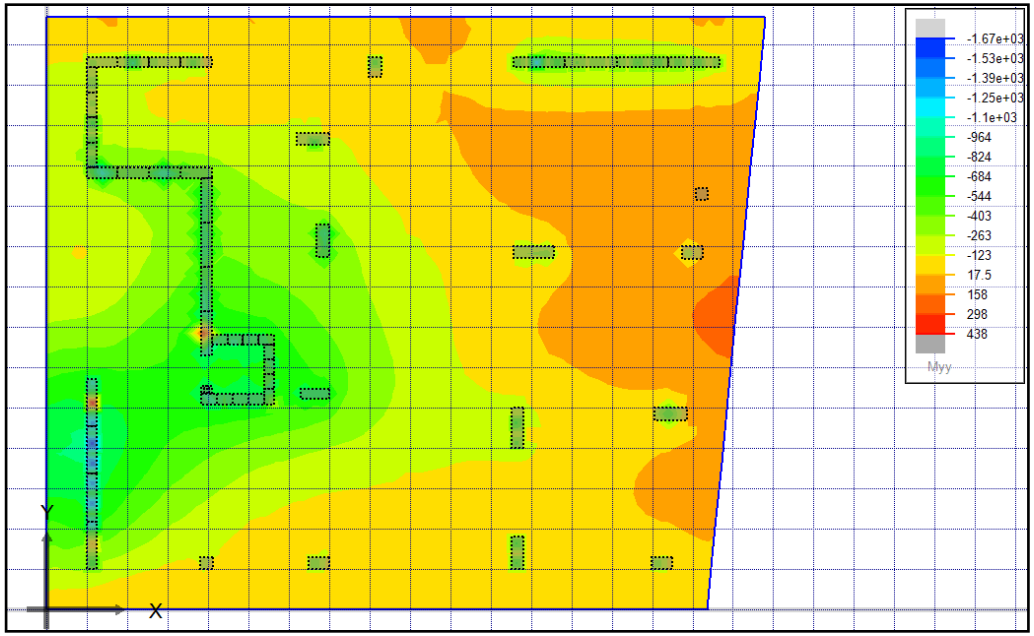


Soil support reactions.

Practical Example



Straining action on strip.



Moment in Y-direction