Three-Dimensional Finite Element Modeling on Piled-Raft Foundation

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Abstract— Piled-raft foundation is a combination of pile foundation and raft foundation. Capacity of piled-raft foundation used both pile capacity and raft capacity. However, in design piled-raft foundation is always assumed that all load is carried by pile. Even though, the raft has a contribution to carried load in reality. There many way to know the load sharing of piled raft foundation. One of it is using finite element method. This paper explain how to make a model of piled raft foundation using finite element method.

Index Terms— Piled-raft foundation, finite element method, load sharing.

1 Introduction

DESIGN of piled-raft foundation in Indonesia is always using a conventional method which mean all the applied load is carried by piles. This design concept is conservative but somehow its unusefull and the design become so expensive.

Recently, Indonesia has published Standar Nasional Indonesia (SNI) for geotechnical design requirement. It's said that for piled-raft foundation, load carried by raft is limited to 25% of total load. Which is this requirement is not applicable for all piled-raft foundation design. Katzenbach said that piles can carried load between 30% and 90%, depends on a number of factors.

2 Piled-raft Foundation

Piled-raft foundation is a combination of pile foundation and raft foundation. Capacity of piled-raft foundation used both pile capacity and raft capacity. There many way to know the load sharing between the raft and piles of piled raft foundation. One of it is using finite element method.

The load sharing between the raft and piles is affected by a number of factors. In the same factor but different settlement will give a different load sharing. That's why settlement of piled raft foundation is the most important factor. Some research has been done and show that load sharing between the raft and piles depend on pile dimension, pile spacing, number of pile, and stiffness of the sub-soil.

3 Finited Element Model

Finite element method is a method of approximation to continuum problems. To solve the problems, the element need to be discrete into a smaller element. Each element have one equation and diffrerent boundary condition. The rebuild the global equation of the big element to solve the problems. With a digital computers, discrete problems can be solved easily.

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4 Modeling Piled-raft Foundation in Plaxis 3D

Plaxis 3D is a three-dimensional finite element program which is used for various types of geotechnical applications. Coordinate system and sign convention shown in Fig 1.

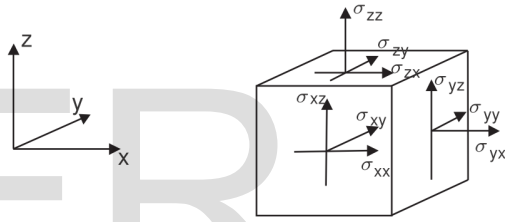

Fig. 1. Coordinate System and Indication of Positive Stress Components

There is two sub programs which is input and output. Input program is used to define a geometry, create a mesh, and define calculation phases. Output program is used to inspect the result of calculation in a three dimensional view or in cross section.

5 Input

When start a new project, project window will appear. There is project tabsheet and model tabsheet as show in Figure 2 and Figure 3. Project tabsheet to enter title and comments of the project and model tabsheet to set unit.

5.1 Soil

Create a borholes to define a soil stratification dan ground water level as shown in Figure 4. Soil material parameter can be input on material sets. In piled-raft foundation case, Mohr-Coulomb model or Hardening Soil model can be used. Mohr-Coulomb model can be used if there is no excavation. But mostly Hardening Soil model is used for piled-raft foundation beacause Mohr-Coulomb only can be used as first approximation and can't modeling unloading reloading modulus on soil behaviour. Drainage type assigned drained, because in drained condition maximum settlement of piled-raft foundation is occur. Material model and drainage type can be input in general tabsheet of the soil and in-

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terface data set window as shown in Figure 5.

5.2 Plate

Plate is thin two dimensional structural object with a rigidity. Raft in piled-raft foundation is using this structural element. Figure 6 show a plate properties that need to be input.

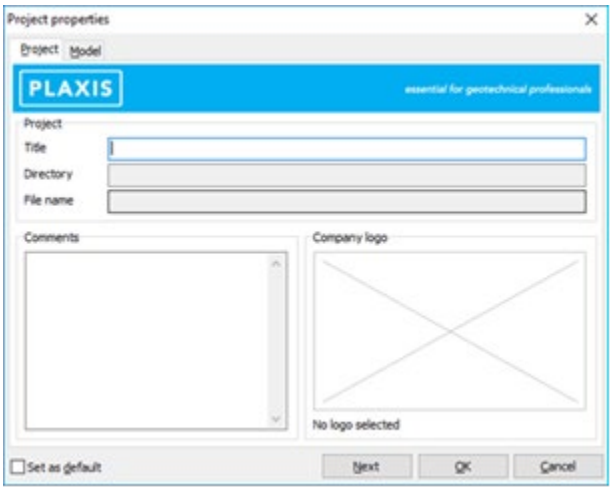

Fig. 2. Project Tabsheet of the Project Properties Window

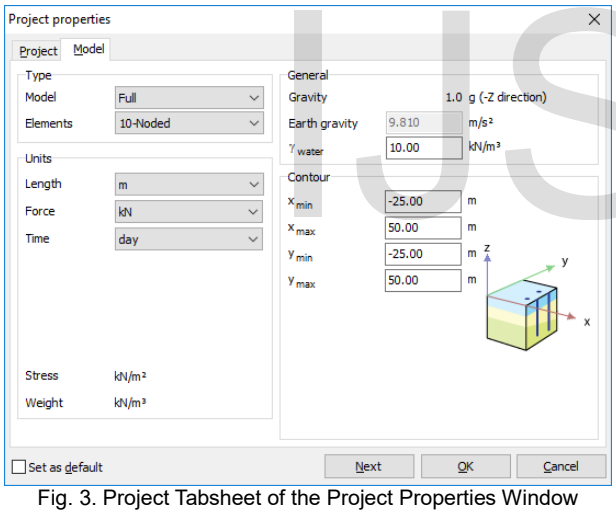

Fig. 3. Project Tabsheet of the Project Properties Window

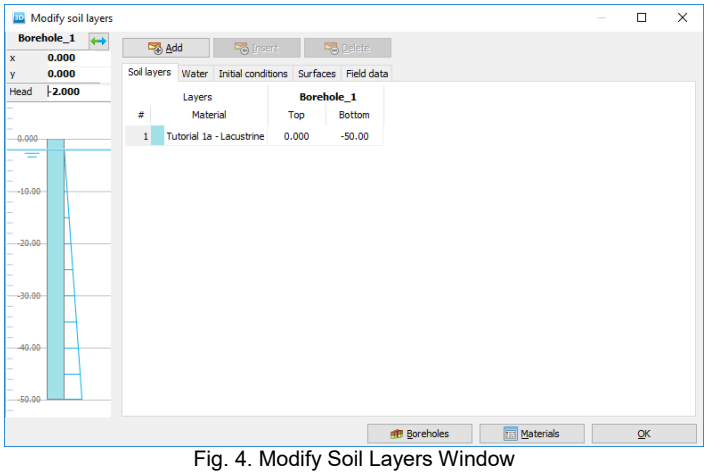

Fig. 4. Modify Soil Layers Window

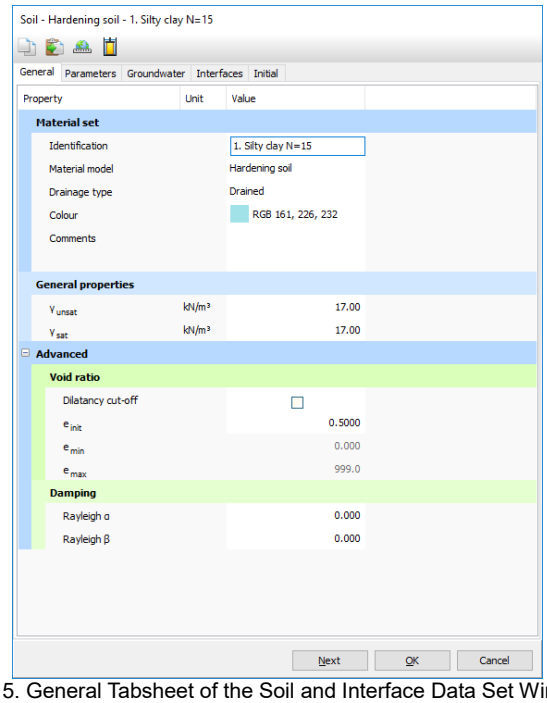

Fig. 5. General Tabsheet of the Soil and Interface Data Set Window

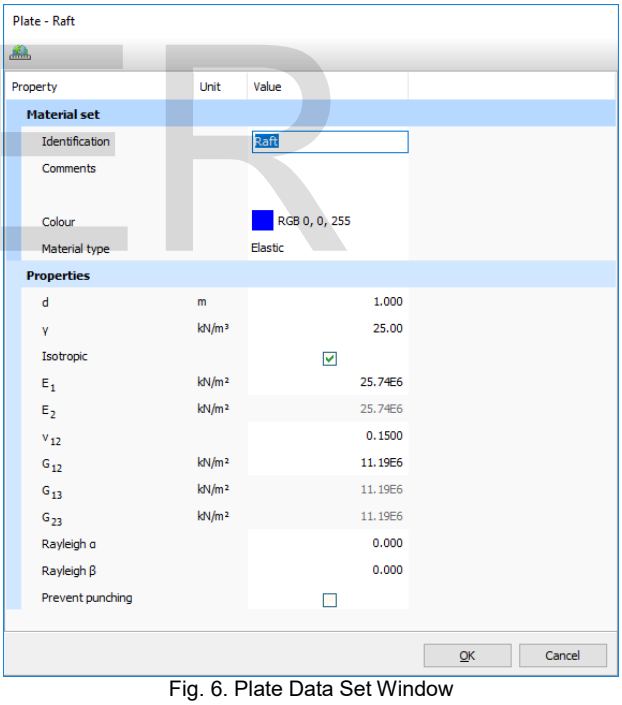

Fig. 6. Plate Data Set Window

5.3 Embedded Beam

Embedded beam is structural object such as a pile in pile-raft foundation. Embedded has a special interface element that involve a skin resistance as well as a foot resistance. Pile material choose linear and skin resistance choose layer dependent as shown in Figure 7.

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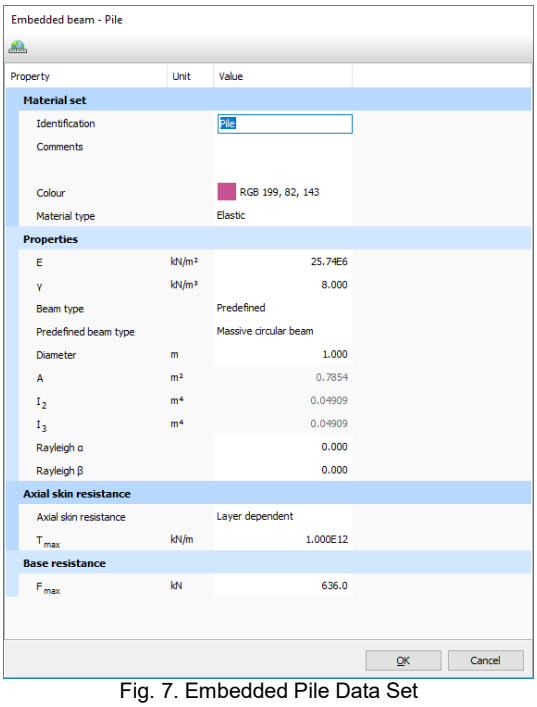

Fig. 7. Embedded Pile Data Set

5.4 Load

There is three type of load that can be applied: point load, line load and surface load. Usually point load is use as a column load. Line load is use as a wall load. At last, surface load is use for shear wall load in tower area.

5.5 Meshing

Meshing is discrete the geometry into a finite element. The mesh can be refine or just used the default medium mesh. To refine the mesh, clik the refine mesh button in the side toolbar and click the area that want to be refine. More refine the mesh, more accurate the result. To view mesh click the view mesh button and a new window is opened displaying the generated mesh as shown in Figure 8.

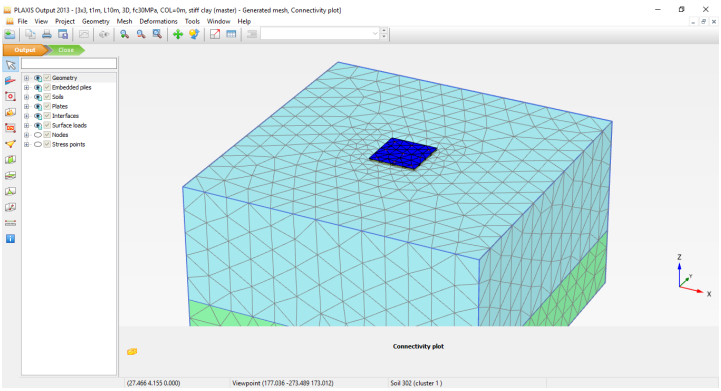

Fig. 8. Meshing in The Output Window

5.6 Calculation

Calculation phases is representing construction stage or loading stage. In piled-raft foundation there is only three calculation phase: initial phase, contruction of piles and raft, and loading (contruction of upper structure). At initial phase there is two type of analysis, which is Ko procedure an Gravity loading. Ko procedure only can be use when all soil layers and phreatic levels parallel to the surface. For all other cases, Gravity loading should be used. Contruction of piles and raft phase, the displacement must reset to zero, so the displacement at loading phase is pure happen because the loading, not because the contruction of pils and raft.

6 Output

Output of this cases is displacement, moment force, shear force, and normal force at raft and at piles. Total of normal force of the piles is a total load carried by piles. Total load carried by raft is a total load applied on the piled-raft foundation minus total load carried by piles. Other ways to find total load carried by raft is using average effective stress below the raft.

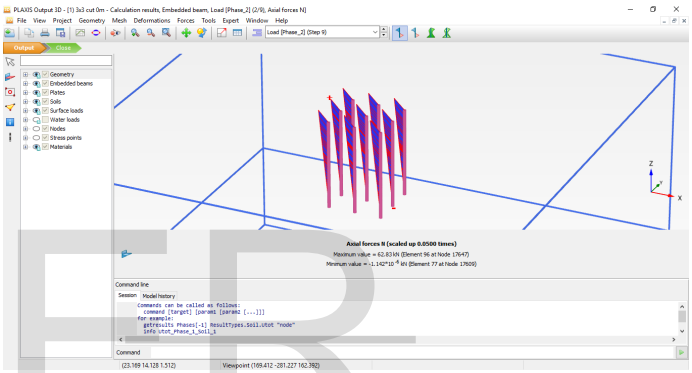
Fig. 9. Output

7 Conclusion

Design of piled-raft foundation is depend on load sharing between the raft dan piles. Load sharing between the raft dan piles affected by a number of factors, such as piled dimension, pile spacing, number of pile, and stiffness of the sub-soil. By modelling piled-raft foundation using finite element method, percentage load carried by raft can be known.

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