ANALYSIS OF LIGHTWEIGHT CONCRETE "CAKAR AYAM" FOUNDATION FOR ROAD CONSTRUCTION USING PLAXIS 3D FOUNDATION SOFTWARE

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OUTLINE OF PRESENTATION

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INTRODUCTION

- Foundation is an extremely important structure element in every construction, such as buildings, bridges, dam and roads.
- A foundation is defined as that part of the structure that supports the weight of the structure and transmits the load to underlying soil or rock.
- Road construction on the soft soil, such as soft clay, peat, and organic soil has been considered a tough challenge.
- Failure of soil can be improved using the implementation of foundation on road.

INTRODUCTION (cont'd)

- The purpose of a foundation is to hold up and hold together the structure above it.
- That is important to ensure that the foundation is really in a good condition to avoid the failure of structure or road construction
- The functions of foundation is to reduce the rate of settlement of soil.

PROBLEM STATEMENT

- Road construction on the soil, often being a main problem in Malaysia. It is because low strength and high compressibility are typical characteristics of this soil.
- Previous studies proved that the applications of foundation are relevant to improve the bearing capacity and reduce the rate of settlement of soil.
- It is called chicken foot foundation method, introduced by Professor Sediyatmo originated from Indonesia. Chicken foot foundation also known as “cakar ayam” foundation.
- Usage of this system has been applied in the construction of roads in Indonesia.

PROBLEM STATEMENT (cont'd)

Figure 1 : Failure of rural road constructed on soft soil at Batu Pahat, Johor. (AHM Nor et al, 2014)

OBJECTIVES OF STUDY

- Determine the rate of settlement of lightweight concrete “cakar ayam” foundation design, on soft clay, clayey silt and sand, under the different axle load, using Plaxis 3D foundation software.
- Determine the effectiveness of lightweight concrete “cakar ayam”foundation design, on soft clay, clayey silt and sand.

SCOPE AND LIMITATION

- The study focuses on the design of lightweight concrete “cakar ayam” foundation design, on soft clay, clayey silt and sand.
- The soil data and lightweight concrete data is provided from previous researchers and from plaxis bulletin.
- To achieve the objective of the research, this study is designed and analyzed using Plaxis 3D foundation software.

SCOPE AND LIMITATION (cont'd)

- Several model of lightweight concrete "cakar ayam" foundation are designed, with 200 mm thickness of slab, and 1.3m, 1.6 m, 1.9m 2.2 m and 2.5 m length of "cakar ayam" foundation.
- The column size is 0.5 x 0.5 m with the spacing 0.75 m each one.
- Every model is tested by different axle load which is 5kN/m^2,10kN/m^2,15kN/m^2, 20kN/m^2, 25kN/m^2, 30kN/m^2, 35kN/m^2 and 40kN/m^2.

LITERATURE REVIEW

TYPE OF SOIL

- Soil can be divided to three very general categories which are cohesionless, cohesive and organic soil. Gravel, sand and silt particles do not tend to stick together, so that they were in cohesionless categories.
- Whilst, cohesive soils are soil that characterized by very small particle size and the particles tend to stick to others. Soft soils pose high moisture content, low shear strength and exhibits high compressibility.

LITERATURE REVIEW (cont'd)

TYPE OF SOIL

- AASTHO system stated that clay particles are less than0.002mm size while USCS system classified that silt and clay in the same grain sizes which are less than 0.075mm. Besides that, sand is classified as a soil that passing 2 mm sieve and retain on 0.075 sieve size based on AASTHO classification system.
- AASTHO also classified that soil criteria based on their plasticity. When the fine fraction of the soil has a plasticity index of 10 and less, it is called silty. The term clayey is applied when the fine fraction have a plasticity index of 11 or more.

LITERATURE REVIEW (cont'd)

"CAKAR AYAM" FOUNDATION

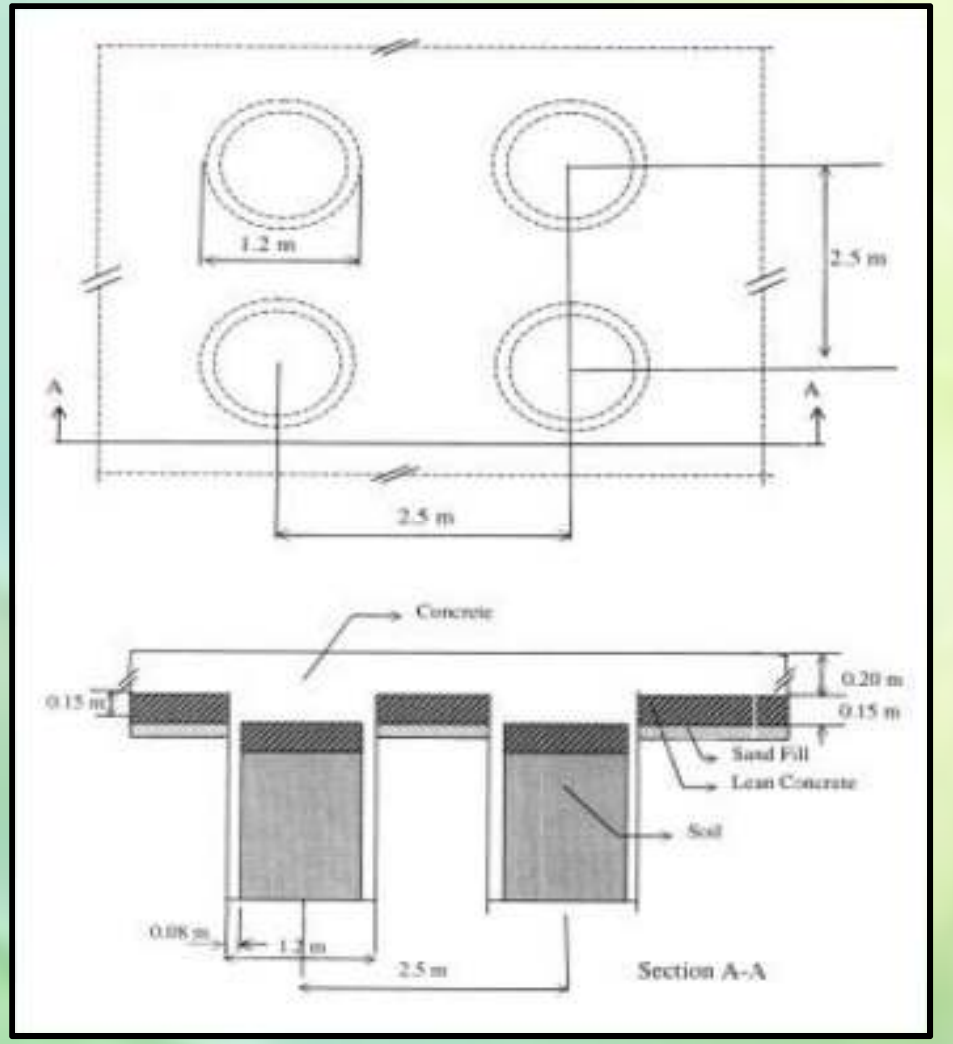

Figure 2: "Cakar Ayam" foundation (Tandjiria, 1999)

LITERATURE REVIEW (cont'd)

"CAKAR AYAM" FOUNDATION

- Basic concept of chicken foot foundation is considered as passive soils that create pressure stiff conditions in the combination of slab and pipe.
- This means that the thin concrete slab, floating above the ground, and pipes remain vertical due to passive pressure.
- The foundation was originally proposed to overcome displacement problems of structures resting on very soft soils(Tandjiria, 1999).

LITERATURE REVIEW (cont'd)

LIGHTWEIGHT CONCRETE

- The properties those are effective with maximum density of about 1760 kg/m^3, and a compressive strength of approximately 28 MPa. The main advantage of using lightweight concrete was it will reduce dead load.
- According to ACI 212R-03 the Poisson's ratio of lightweight concrete value varied between 0.16 and 0.25 with the average being 0.21. A value of 0.20 may be usually assumed for practical design purposes.

METERIAL AND METHODS

- There are several properties used in plaxis 3D foundation software.
- A few steps have to be done in order to design the foundation using Plaxis 3D foundation software, which is its general setting, soil parameter, geometry of model and calculation steps.
- The parameters used in the steps are soil parameter, lightweight concrete parameter and load distribution value.
- Table 1 shows the properties of soil that were used in Plaxis 3D foundation software which was obtained from previous researcher data. Soft clay soil is the soil which was obtained from RECESS, UTHM. Clayey silt soil data was obtained from Plaxis buletin. While sand data was obtained from Plaxis 3D foundation manual.

METERIAL AND METHODS (cont'd)

Description	Symbol	Unit	Soft clay		Sand	Clayey silt
			0-3.5 m	3.5-10 m		
General						
Material model	Model		Hardening soil model			
Drainage type	Type		Undrained		Drained	Drained
Unit weight above phreatic level	γ_{unsat}	kN/m^3	8.190	12.550	17.0	20.000
Unit weight below phreatic level	γ_{sat}	kN/m^3	15.075	17.32	20.0	20.200
Parameters						
Stiffness						
Secant stiffness for CD triaxial test	(E_{50}^{ref})	kN/m^2	1655.854	2206.588	43000	25000
Tangen odeometer stiffness	(E_{ur}^{ref})	kN/m^2	1324.684	1765.271	43000	25000
Unloading/realoading stiffness	(E_{eod}^{ref})	kN/m^2	10460.00	5642.000	129000	75000
Power for stress level dependency of stiffness	M	-	0.85	0.78	0.50	0.80
Strength						
Cohesion	c'	kN/m^2	7	10	1	25
Friction angle	Φ	-	27	30	34	26
Dilatancy angle	Ψ	-	0	0	4	0
Interfaces						
Strength						
Interface reduction factor	R_{inter}	-	0.5	0.5	0.7	1.0

Table1: Hardening soil model parameter

RESULTS AND DISSCUSSIONS

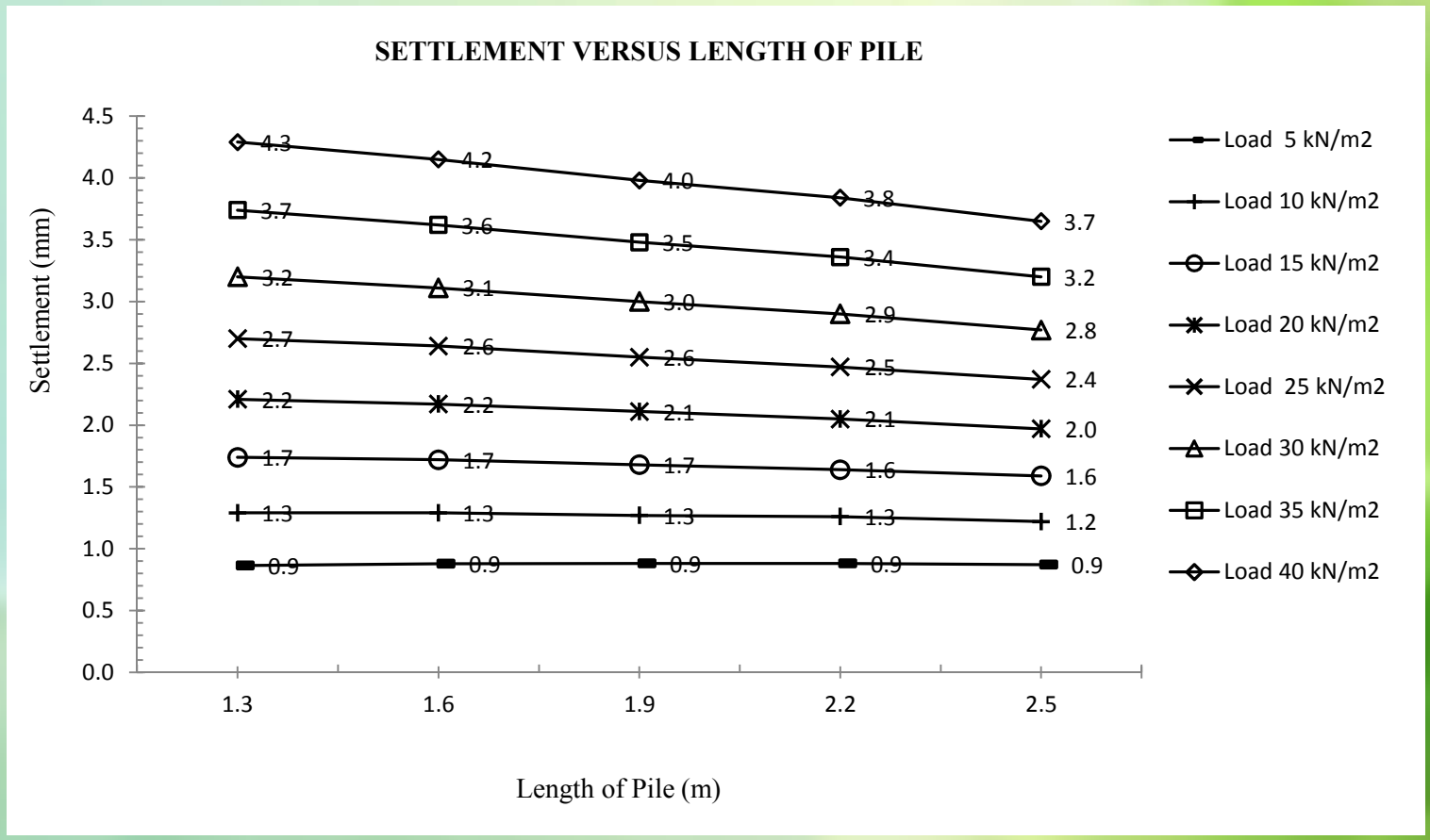

Figure 3 Graph settlements versus length of pile on clayey silt, with different distribution load

RESULTS AND DISSCUSSIONS (cont'd)

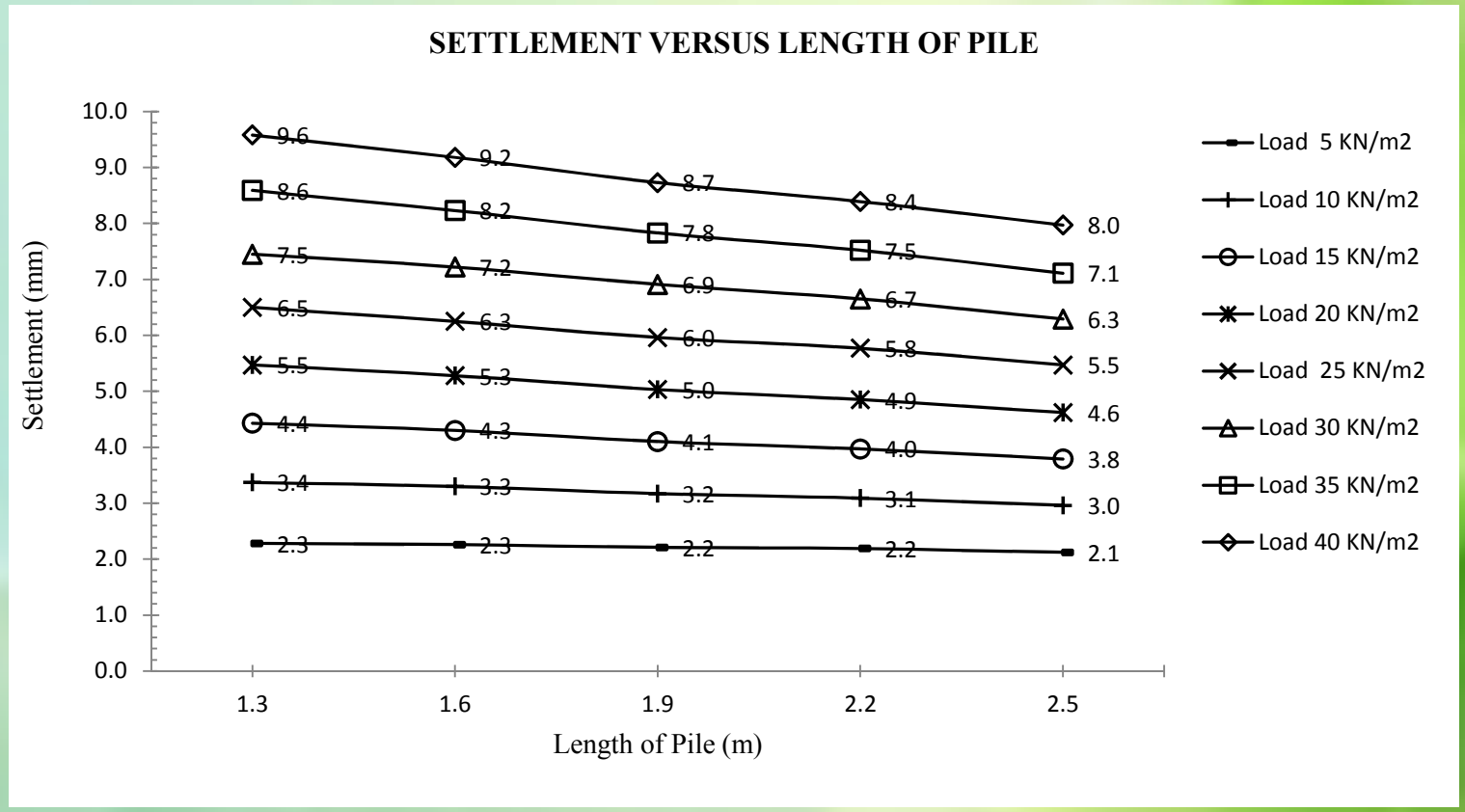

Figure 4 Graph settlement versus length of pile on sand, with different distribution load

RESULTS AND DISSCUSSIONS (cont'd)

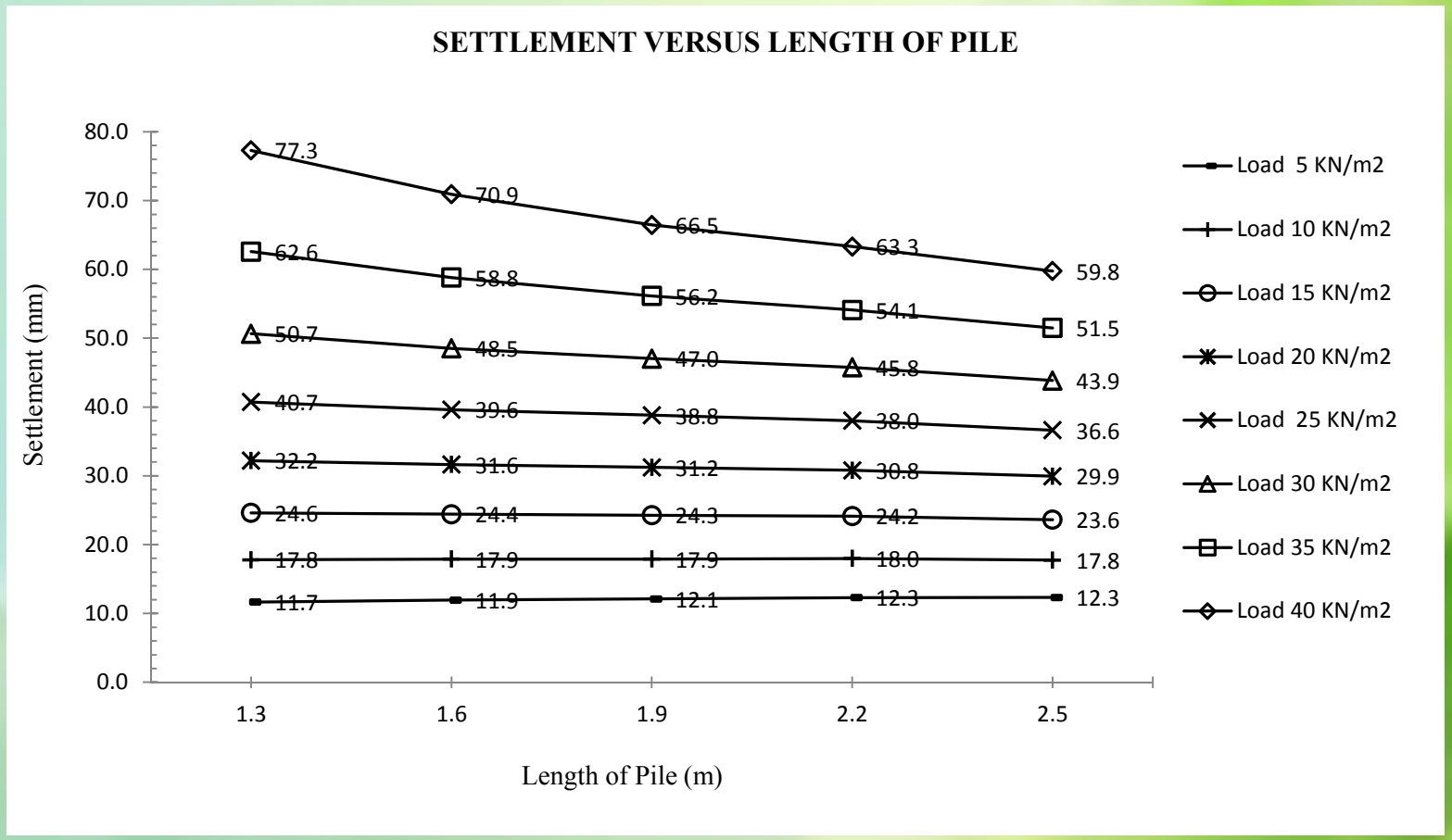

Figure 5 Graph settlement versus length of pile on softclay, with different distribution load

RESULTS AND DISSCUSSIONS (cont'd)

- The figure 3 it is shown that the foundation on soft clay can only be acceptable when load of 5KN/m^2, 10 KN/m^2, and 15 KN/m^2 were applied. Started from the load of 20 KN/m^2, the value of settlement exceeded the limit which is 25 mm. So that the foundation concept is not suitable to be applied on soft clay soil.

- This is due to the properties of soil that are not suitable to apply this concept. Having been discussed that, soft soils posed high moisture content, low shear strength and exhibits high compressibility.

- The figure 4, it can be seen that the value of settlement on foundation is acceptable when loads were applied on sand. The value of settlement decreased when lengths of pile increased. Therefore, the foundation concept is suitable to be applied on sand.

RESULTS AND DISSCUSSIONS (cont'd)

- Properties of the sand support the implementation of the "cakar ayam" foundation concept. It would help in reducing the value of the settlement. The value of cohesion of the sand is low, but its value of friction is high. The value of friction of the sand will help to increase the strength of the soil. It can be seen based on the formula of shear strength parameter in terms of effective stress. Sand stiffness parameter is high which will help to reduce the value of the settlement. This is due to the stiffness values which also depends on the effective stress value of the sand. Rotation of the pipe columns will be counter back by the lateral earth pressure, that are acting around the pipe columns. So that passive pressure will help to reduce the settlement value.

RESULTS AND DISSCUSSIONS (cont'd)

- From the figure, it can be seen that the value of settlement on the foundation is acceptable when loads were applied on clayey silt. The value of settlement decreased when lengths of pile increased. So that the foundation concept is suitable to be applied on clayey silt.

- The properties of clayey silt would help the implementation of the "cakar ayam" foundation concept. It will help to reduce the value of the settlement. The value of cohesion and friction of soil is high. This will help to increase the strength of the soil. It can be seen based on the formula of shear strength parameter in terms of effective stress.

RESULTS AND DISSCUSSIONS (cont'd)

- Furthermore, clayey silt stiffness parameter is high which could help in reducing the value of the settlement. Deflection that occurs on the concrete slab of "cakar ayam" foundation will cause the pipe columns to rotate about its axis. Rotation of the pipe columns will be counter back by the lateral earth pressure, that are acting around the pipe columns. So that passive pressure will help to reduce the settlement value.

- Overall, the value of the settlement also is rather low due to the unit weight of lightweight concrete which will reduce the value of the settlement results. It would make the settlement value more safe.

CONCLUSION

- The results show that the lightweight “cakar ayam” foundation concept was suitable to be implemented on sand and clayey silt soils. This is because of all the value obtained from Plaxis 3D foundation software are acceptable, which is under the safe limit, 25 mm.
- The trends of the settlement also show that when the lengths of “cakar ayam” foundation increase, the values of settlement decrease.
- Besides that, this concept is still not suitable to be implemented on soft clay soil. This is because the results show that the settlement value obtained from Plaxis 3D foundation software, are still over the limit.

CONCLUSION (cont'd)

- The results also show that the value of settlement was relatively low. This is affected from the implementation of lightweight concrete "cakar ayam" foundation.
- The unit weight of concrete is low. This will reduce the selfweight of foundation and the value of the settlement. Nevertheless, the research was addressing their objective.

Recommendation

- Studies of “cakar ayam” foundation concept can be implemented on others soil type, using Plaxis 3D foundation software.
- Studies also need to get the detailed information properties of soil on the site, during the project implementation. This is because usually in road construction, soil compacted that will causes of soil properties change. While this method is not conducted and analysis in Plaxis 3D foundation software.
- Determine the way how to overcome the “cakar ayam” foundation problem on soft such as soft clay soil.If “cakar ayam” foundation still not suitable for implementation in soft clay soil, the soil must be stabilized first, before the implementation of “cakar ayam” foundation concept.

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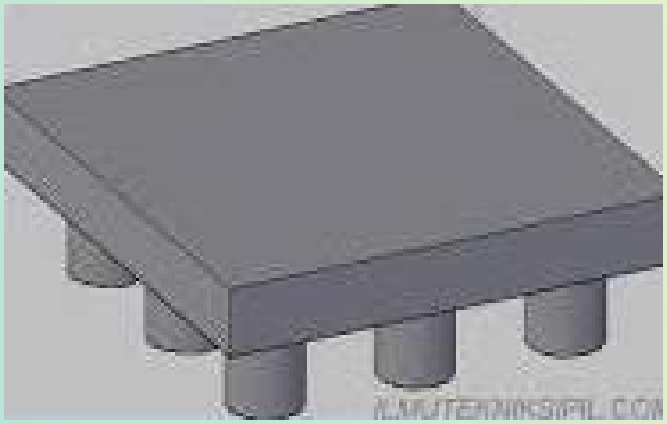

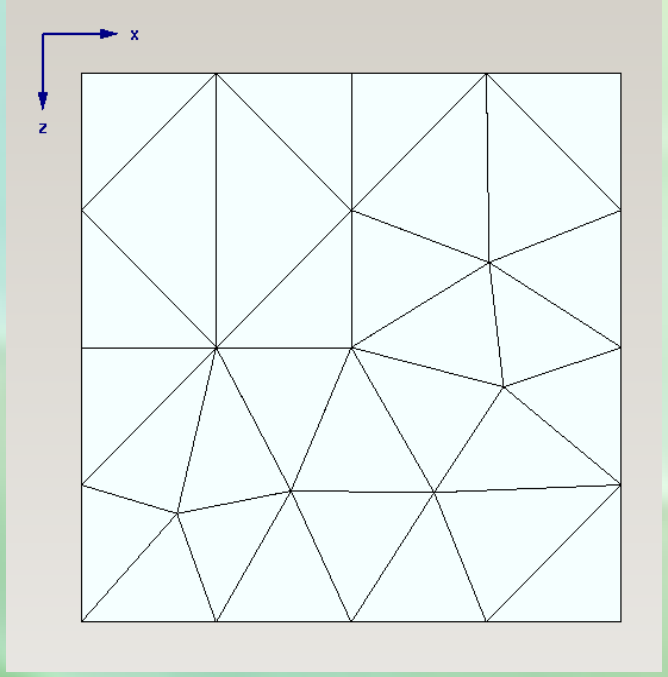

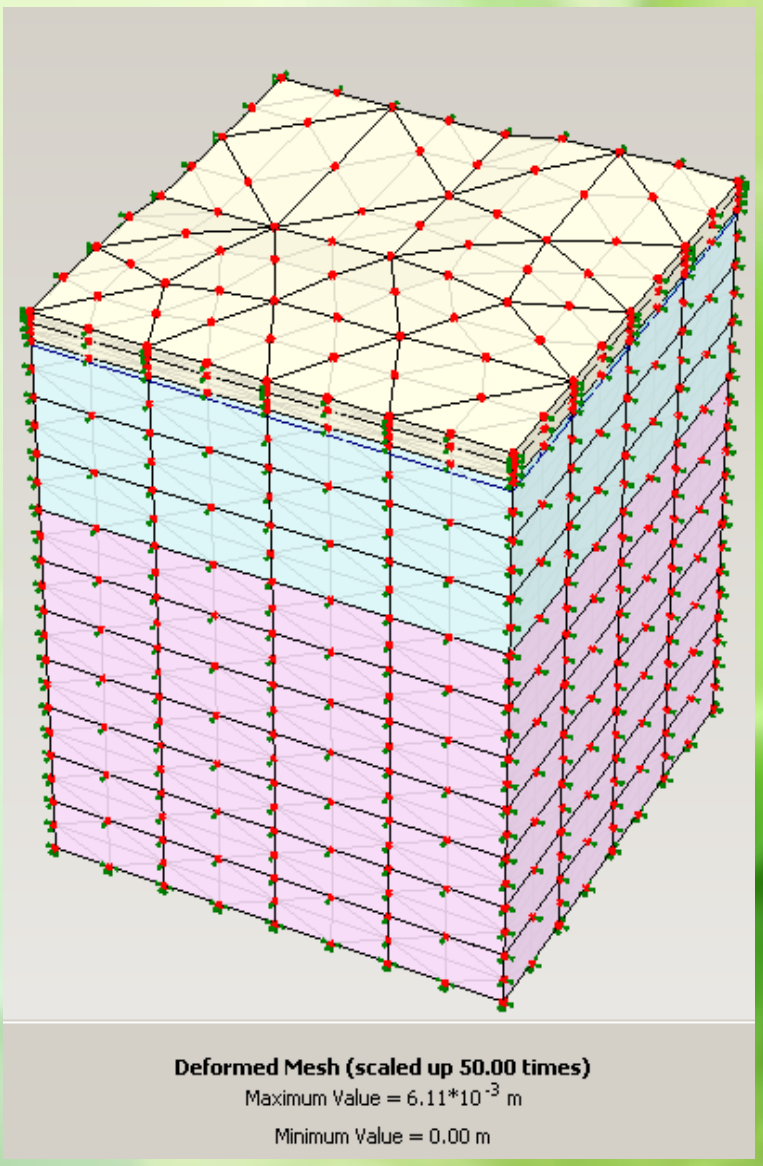

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