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Correlation of Permeability Coefficient and Coefficient of Consolidation in Pontianak City's Soft Soil

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Abstract
Soft soil is a type of soil that is difficult to use in construction because it has a low bearing capacity and slow settlement due to its fine grain size. In statistics, the relationship or correlation between two data can be predicted using mathematical formulas to find out how much the two data can influence each other. Most of the soil on the surface of the city of Pontianak is dominated by soft soil, so it is important to know how much the coefficient of consolidation and coefficient of permeability can influence each other. From the results of the regression and correlation calculations, the relationship between the permeability coefficient and the consolidation coefficient for the combination of original soil and sand mixed soil is y = 674.7x + 0.0003 with a value of r = 0.4834. The relationship between the permeability coefficient and the original soil consolidation coefficient is y = 321.4x + 0.0003 with a value of r = 0.4173. The relationship between the coefficient of permeability and the coefficient of consolidation of the sand mixed soil is y = 1295.5x + 0.0003 with a value of r = 0.7994. from the experimental results, it can be concluded that there is a significant influence between the value of the permeability coefficient and the consolidation coefficient

Keywords: consolidation, correlation, permeability, regression, soft soil

1. Introduction

The Foundation of the building is one of the most important parts of construction because every building has been found buried on the ground. Therefore, a planner needs to know the soil properties because they will directly affect the buildings above them.

Soft soil has a low bearing capacity and because of its fine grain size, the time required to achieve maximum settlement due to consolidation becomes slow because the water in the soil pores takes a long time to penetrate the soil layer. In determining the time required for consolidation, the planner will usually bring a sample of the soil to be tested on to the laboratory to be examined for consolidation with an oedometer. The consolidation testing process with an oedometer generally takes a long time, which is approximately 8 days. In contrast to consolidation experiments, permeability experiments generally only take 2 days for laboratory testing [1].

From the issues above, we need a way to determine the relationship/correlation between permeability coefficient and coefficient of consolidation of soft soil in Pontianak so that the relationship between them can be determined

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with a mathematical function and can be predicted its value just by looking at one of the known data

2. Theoretical Basis

2.1 Previous Research

Previous research related to permeability coefficient and coefficient of consolidation was presented elsewhere [2], founded that there is a relationship between the permeability coefficient tested using the falling head permeability test method and the permeability coefficient obtained from the consolidation experiment. Another research defined the permeability from the holes at Northern Barbados ridge area [3] which was conducted by W. Bruckmann et al (1997). These studies showed that the porosity and permeability of mutually proportional, but in both studies were not described further on how much the relationship between permeability coefficient and coefficient of consolidation as well as a mathematical equation

2.2 Soil Definition

Soil is a mineral that comes from the remains of weathering of rocks and in Soil civil engineering plays an important role in construction. Grain interlocking between soils can be affected by carbonates, oxides, and organic matter. The space between the particles can contain water, air, or both. (Das, 1995).

2.3 Permeability

Permeability is the ability of a material to pass liquids from the pores of the material. Soil pores are interconnected with each other, so that water can flow from a point with a high energy level to a point with a lower energy level. Generally, for laboratory permeability experiments, there are two methods, falling head, and constant head experimental methods.

2.4 Consolidation

Consolidation is a result of soil deformation due to the load above it which results in the release of water from the soil pores and shrinking soil volume due to the decrease in void ratio. From the consolidation experiment, two types of parameters can be obtained are Cc or compression index and Cv or consolidation coefficient.

2.5 Regression and Correlation

Regression and correlation analysis shows how the relationship between two or more variables affects each other. The value of an unknown variable will be predicted with a certain accuracy based on previous observations about that variable. The greater the value of the correlation coefficient, the greater the relationship between the variables. To know the interpretation of each value of the correlation coefficient can be seen in Table 1.

Table 1. Correlation Coefficient Interpretation [4]

Coefficient	Relationship
0.00	No relationship
0,01 - 0,09	Less significant relationship
0,10 - 0,29	Weak relationship
0,30 - 0,29	Moderate relationship
0,50 - 0,69	Strong relationship
0,70 - 0,89	Very strong relationship
>0,90	Almost perfect relationship

3. research Methodology

3.1 Research Location

The research was conducted at the Soil Mechanics Laboratory, Faculty of Engineering, Tanjungpura University, Pontianak, while the sampling locations were in 3 different locations, which are Universitas Tanjungpura, Jalan Karet, and Jalan Perdana, Pontianak, West Kalimantan, as presented in Fig. 1 to Fig. 3 below.

Figure 1. Sampling Location (Universitas Tanjungpura)

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Figure 2. Sampling Location (Jalan Karet)

Figure 3. Sampling Location (Jalan Perdana)

3.2 Research Methodology

To simplify research, it is necessary to carry out research stages which include:

1. Primary Data as follow:
   a. Examination of original soil properties, including:
      - Water content
      - Volume weight
      - Specific gravity
      - Hydrometer and sieve analysis
      - Atterberg's limit test
      - Permeability test
      - Consolidation test
   b. Soil properties examination of a mixture of 10%, 20%, and 30% sand in soil include:
      - Standard compaction test
      - Specific gravity
      - Hydrometer and sieve analysis
      - Atterberg's limit test
      - Permeability test
      - Consolidation test

The relationship between two variables will be calculated using linear models of regression and correlation analysis.

4. Result and Discussion

As presented in Table 2 below, the permeability coefficient and coefficient of consolidation on original soil and sand mixed soil are significantly increasing.

Table 2. Permeability and Consolidation Test Result

Sample Code	Depth (m)	k (cm/s)	Cv (cm^2/s)
Untan A1	1.5 - 2.0	6.9.E-07	5.2.E-04
Untan B1	2.0 - 2.5	1.4.E-06	8.7.E-04
Untan A2	1.5 - 2.0	8.0.E-07	2.8.E-04
Untan B2	2.0 - 2.5	1.1.E-06	8.0.E-04
Untan 10%	1.5	3.3.E-07	1.1.E-03
Untan 20%	1.5	9.1.E-07	1.3.E-03
Untan 30%	1.5	1.8.E-06	2.5.E-03
Karet A1	1.5 - 2.0	6.9.E-07	1.2.E-03
Karet B1	2.0 - 2.5	3.0.E-07	2.4.E-04
Karet A2	1.5 - 2.0	1.4.E-06	4.3.E-04
Karet B2	2.0 - 2.5	2.9.E-07	4.8.E-04
Karet 10%	1.5	2.8.E-07	3.1.E-04
Karet 20%	1.5	3.2.E-07	6.0.E-04
Karet 30%	1.5	4.6.E-07	1.5.E-03
Perdana A1	1.5 - 2.0	5.3.E-07	1.8.E-04
Perdana B1	2.0 - 2.5	5.5.E-07	2.4.E-04
Perdana A2	1.5 - 2.0	6.9.E-07	3.8.E-04
Perdana B2	2.0 - 2.5	2.3.E-07	3.5.E-04
Perdana 10%	1.5	2.8.E-07	1.9.E-04
Perdana 20%	1.5	3.4.E-07	2.1.E-04
Perdana 30%	1.5	4.5.E-07	1.7.E-03

Table 3. Sand Ratio and Permeability Coefficient Comparison

Location	Sand Ratio	k (cm/s)
Untan	10%	3.29856E-07
	20%	9.10252E-07
	30%	1.75587E-06
Karet	10%	2.83778E-07
	20%	3.18319E-07
	30%	4.57558E-07
Perdana	10%	2.83778E-07
	20%	3.41406E-07
	30%	4.45888E-07

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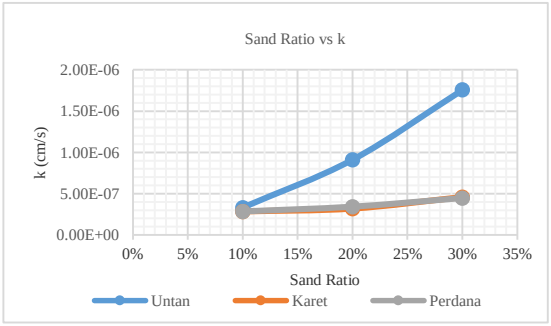

Figure 4. Sand Ratio vs k Graph

Table 4. Sand Ratio and Coefficient of Consolidation Comparison

Location	Sand Ratio	Cv (cm^2/s)
Untan	10%	0.00105
	20%	0.0013
	30%	0.0025
Jalan Karet	10%	0.000305
	20%	0.0006
	30%	0.00145
Jalan Perdana	10%	0.000185
	20%	0.00021
	30%	0.0017

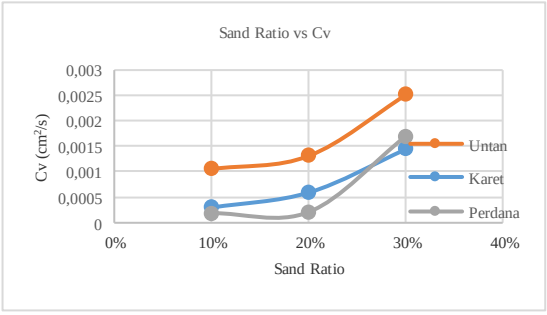

Figure 5. Sand Ratio vs Cv Graph

From the table and graph described above, it can be seen that with the increase in the ratio of sand in the soil, the permeability value will increase and the coefficient of consolidation value will also increase. This happens because the more sand fraction is mixed in the original soil, the grain size distribution will become irregular so that the void value will increase which causes the permeability coefficient value to increase.

4.1 Relationship between Permeability Coefficient (k) and Consolidation Coefficient (Cv) Original Soil and Sand Mixed Soil

The relationship between the permeability coefficient and the consolidation coefficient can be seen in Figure 6 below.

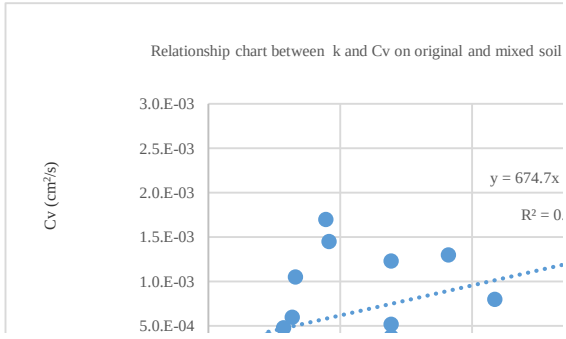

Figure 6. Relationship chart between k and Cv on original and mixed soil

From the calculation results, it is found that the relationship between the permeability coefficient and the coefficient of consolidation for the combined soil between the original soil and sand mixed soil with a ratio of 10%, 20%, and 30% is y = 674.7x+0.0003 and has a correlation coefficient value of 0.4834, so the relationship between the permeability coefficient and the coefficient of consolidation for the combined soil can be determined as a moderate relationship.

4.2 Relationship between Permeability Coefficient (k) and Consolidation Coefficient (Cv) Original Soil.

The relationship between the permeability coefficient and the consolidation coefficient can be seen in Figure 7 below.

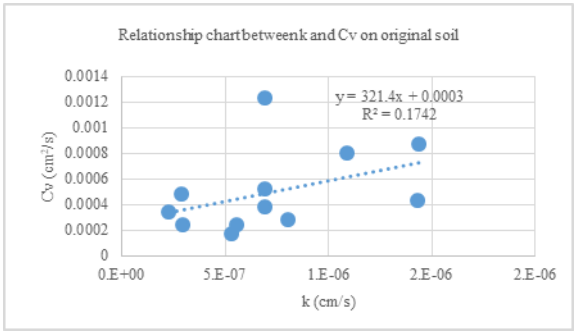

Figure 7. Relationship chart between k and Cv on the original soil

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From the calculation results, it is found that the relationship between the permeability coefficient and the coefficient of consolidation for the original soil is y = 321.4x+0.0003 and has a correlation coefficient value of 0.4173, so the relationship between the permeability coefficient and the coefficient of consolidation for the combined soil can be determined as a moderate relationship.

4.3 Relationship between Permeability Coefficient (k) and Consolidation Coefficient (Cv) on sand mixed Soil.

The relationship between the permeability coefficient and the consolidation coefficient can be seen in Figure 8 below.

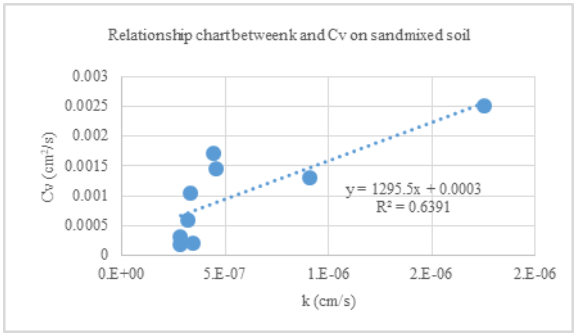

Figure 8. Relationship chart between k and Cv on sand mixed soil

From the calculation results, it is found that the relationship between the permeability coefficient and the coefficient of consolidation for the original soil is y = 1295.5x+0.0003 and has a correlation coefficient value of 0.799, so the relationship between the permeability coefficient and the coefficient of consolidation for the combined soil can be determined as a very strong relationship.

4.4 Relationship between Sand Mixture Ratio and Compression Index (Cc) of Sand Mixed Soil.

The relationship between the permeability coefficient and the consolidation coefficient can be seen in Figure 9 below.

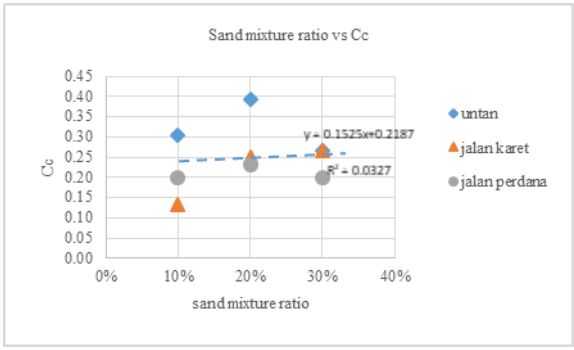

Figure 9. Relationship chart between sand mixture ratio and Cc on sand mixed soil

From the calculation results, it is found that the relationship between the sand mixture ratio and the compression index for sand mixed soil is y =0.1525x+0.2187 and has a correlation coefficient value of 0.18, then the relationship between the coefficient of permeability and the coefficient of consolidation for sand-mixed soil can be determined as a weak relationship.

5. Conclusion

From these data, several conclusions can be drawn. There is a moderate correlation between the value of the laboratory permeability coefficient (k) and the laboratory consolidation coefficient (Cv) in the combined soil between the original soil and the mixed sand soil with a ratio of 10%, 20%, and 30. % with linear regression equation y = 674.7x + 0.0003 and has a correlation coefficient value of r = 0.4834. There is a moderate correlation between the laboratory permeability coefficient (k) and the laboratory consolidation coefficient (Cv) on the original soil with a linear regression equation y = 321.4x + 0.0003 and has a correlation coefficient value of r = 0.4173. There is a very strong correlation between the value of the coefficient of permeability (k) laboratory to the value of the coefficient of consolidation (Cv) laboratory on a sand mixture with a ratio of 10%, 20%, and 30% with the linear regression equation y = 1295.5x + 0.0003 and has a value of correlation coefficient r = 0.7994. There is no significant relationship between the sand mixing ratio and the value of the compression index (Cc) in a sand-mixed soil. The greater the percentage of the sand mixture in the original soil will increase the value of the permeability coefficient, specific gravity value, and affect the value of the consolidation coefficient.

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