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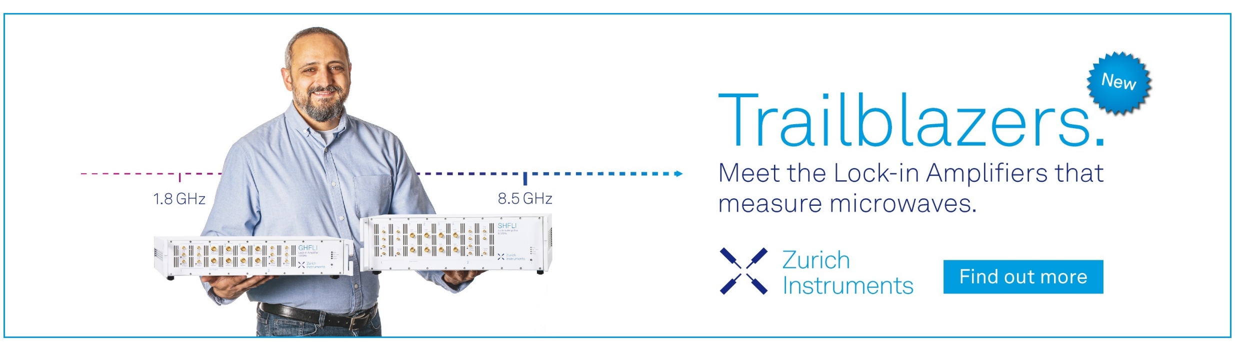

Biplot Analysis for Mapping the Soil Sample Characteristics of Rawa Jitu, Marga Tiga, and Teluk Ratai, Lampung Province

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Abstract. The purpose of biplot analysis is to demonstrate a matrix by overlapping the vectors representing the row vectors with the vectors representing the column vectors of the matrix. Biplot is performed by outlining singular value decomposition (SVD). SVD aims to describe the singular value of the Y matrix which is an X matrix of size n x p which has been corrected with the mean and followed by the generation of the G and H matrices. Biplot results. The results of the biplot analysis on 3 groups of soil samples based on the similarity of soil characteristics for the Rawa Jitu and Marga Tiga areas are as follows: group 1 consists of soil samples that have the same maximum dry density, California bearing ratio, and specific weight of solids; group 2 consists of soil samples that have the similar Atterberg Plastic Limit, Atterberg Liquid Limit, and Atterberg Plasticity Index; while group 3 consisted of soil samples which had similar moisture content and optimum moisture content, and % Lose No. 200. It is different with the Teluk Ratai area where there are 2 groups of soil samples including group 1 consisting of soil samples that have the same maximum dry density, and % passing filter No. 200; group 2 consists of soil samples that have similarities from test results using the CBR or California Bearing Ratio, Atterberg Plastic Limit, Atterberg Liquid Limit, moisture content, and optimum moisture content. The highest diversity so that it can be said as a relatively high soil characteristic in Margatiga and Rawa Jitu is % Lose No. 200, while in the Teluk Ratai area, the highest diversity is at the Atterberg Liquid Limit. If there is an increase in the water content in the soil sample, then the Atterberg Liquid Limit and Atterberg Liquid Limit values will also increase and vice versa if the % passes filter No. 200 is smaller, there will be an increase in the CBR value.

INTRODUCTION

Dillon and Goldstein (1984) explain that multiple variable analysis (APG) is defined as all statistical methods that analyze several measurements (variables) in each object in one or many samples simultaneously [1]. APG is a statistical method that is associated with more than two variables or many variables that are observed as the variables influence each other.

Biplot analysis was first introduced by Gabriel in 1971 and has been further developed by Gower and Hand in 1996. This analysis is an attempt to provide a graphical representation of the data matrix X in a plot by superimposing vectors in a low-dimensional space [2,3]. This analysis is used in positioning and perceptual mapping of a set of objects (rows of the X data matrix). Biplot analysis in the process requires data from several objects with attributes (columns of the X data matrix) measured by interval and ratio scales. The final result of this analysis is displayed in the form of a two-dimensional image display that contains related information:

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1. The relative position of the object. Based on this information, two objects that have the closest distance are said to have a high degree of similarity based on the observed attributes.
2. Relationships between attributes. From this information, it will be known about the linear relationship (correlation) between attributes and the level of importance of an attribute based on its variance.
3. The combination of information (1) and (2) is known as a bi-plot where the characteristics of each object will be known based on the observed attributes. This research was conducted to determine the mapping of soil sample characteristics in the areas of Rawajitu, Margatiga, and Teluk Ratai, Lampung Province based on biplot analysis.

LITERATURE REVIEW

Biplot Analysis

Rencher (2002) describes that the graph in the biplot analysis is based on principal component analysis (PCA biplot), namely by describing the singular value decomposition (SVD) [4]. SVD aims to describe the singular value of the **Y** which is an X matrix of size n x p that has been corrected with the mean, and then **G** and **H** matrices are generated. For example, the ${}_n\mathbf{X}_p$ matrix is the data matrix and ${}_n\mathbf{Y}_p$ is the data matrix that has been corrected to the middle value. Thus, by the singular value decomposition will be obtained:

$$Y_{nxm} = U_{nxp} \quad L_{pxp} \quad V^T_{pxm} \tag{1}$$

Where: $\boldsymbol{Y_{nxm}}$= is a corrected matrix with the mean for example from an ${}_n\mathbf{X}_p$ data matrix
$\boldsymbol{U_{nxp}}$ = is an eigenvector matrix of $\mathbf{YY^T}$
$\boldsymbol{L_{pxp}}$ = in the form of a diagonal matrix with a root eigenvalue of the matrix **U**
And or matrix **V**
$\boldsymbol{V_{pxm}}$ = is an eigenvector matrix of $\mathbf{Y^TY}$
Equation (1) may also be written as follows:

$$\boldsymbol{Yn\ xm = Un\ x\ p\ Lp\ x\ p}\ \alpha\ \boldsymbol{Lp\ x\ p}\ 1\text{-}\alpha\ \boldsymbol{VTp\ x\ m} \tag{2}$$

$$\boldsymbol{Y_{n\ x\ m}} = {}_n\mathbf{G}_p\ {}_p\mathbf{H}_m \tag{3}$$

by defining $\mathbf{G}=\boldsymbol{U_{nxp}L_{pxp}}^{\alpha}$ and $\mathbf{H}=\boldsymbol{L_{pxp}}^{1-\alpha}\boldsymbol{V^T_{pxm}}$ and an alpha value of $0,1 \le \alpha \le 1$.

The interpretation of the biplot is performed by determining the value of α. In general, the value of can be chosen by the researcher with consideration to placing more emphasis on the rows or columns of $\boldsymbol{Y_{nxm}}$. If α = 1 is taken, this indicates that the researcher places more emphasis on the $\boldsymbol{Y_{nxm}}$ matrix row (representation of the object). Meanwhile, if α = 0 is taken, it indicates that the researcher places more emphasis on the $\boldsymbol{Y_{nxm}}$ matrix column (variable representation) where the value of α = 0, is called asymmetrical biplot. The alpha value used in this study is α = 1, so that $\mathbf{G} = \boldsymbol{U_{nxp}\ L_{pxp}}$dan $\mathbf{H} = \boldsymbol{V^T_{pxm}}$. Each row of the data matrix or object in this Biplot is represented by a dot in the principal component value pair. The i-th column of the data matrix or variable is indicated by an arrow. The level of suitability (Goodness of fit) of the ***L*** matrix value approach with rank = 2 is [5]:

$$\frac{\lambda_1 + \lambda_2}{\sum_{i=1}^{m} \lambda_i} \tag{4}$$

RESEARCH METHODOLOGY

In this research method, the data sources and variables used, as well as the stages of the research, will be discussed. The data used in this study is the characteristic data of Rawajitu, Margatiga, and Teluk Ratai soil samples. The variables used are as follows, namely water content (W), specific weight of solids (Gs), % Lose No. 200 (percentlose), Atterberg Liquid Limit (LL), Atterberg Plastic Limit (PL), Atterberg Plasticity Index (PI), Maximum dry density (MDD), optimum moisture content (Wopt), and California Bearing Ratio (CBR).

The research steps undertaken to achieve the research objectives are as follows:

4. Performing descriptive statistical analysis of soil characteristics data to obtain an overview of the research variables in areas with varied distributions, which include Rawajitu, Margatiga, and Teluk Ratai. The three areas are far from each other, the distance between the locations is more than 30 km.
5. Mapping the characteristics of the soil samples in the Rawajitu, Margatiga, and Teluk Ratai areas using biplot analysis.
6. Summarize and interpret the results.

RESULTS AND DISCUSSION

Descriptive Statistical Analysis

To determine the characteristics of the soil in the areas mentioned in this study, descriptive statistical analysis was used in terms of various variables as shown in Table 1 as follows.

TABLE 1. Descriptive Soil Samples of Rawajitu, Margatiga, and Teluk Ratai

Variable	Area	Min	Max	Mean	Std
	Rawa Jitu	5,62	56,83	17,6	11,52
W	Margatiga	24,48	44,63	33,09	6,148
	Teluk Ratai	4,69	27,79	15,68	9,84
	Rawa Jitu	2,35	2,64	2,55	0,081
Gs	Margatiga	2,51	2,589	2,564	0,025
	Teluk Ratai	2,427	2,608	2,549	0,073
	Rawa Jitu	15,64	87,58	46,05	20,20
PersenLose	Margatiga	30,240	65,710	48,89	13,46
	Teluk Ratai	31,31	56,20	42,51	9,291
	Rawa Jitu	22,30	63,34	34,50	9,29
LL	Margatiga	38,2	58,52	50,28	7,73
	Teluk Ratai	31,15	63,21	44,62	15,24
	Rawa Jitu	13,92	41,32	23,38	6,472
PL	Margatiga	20,7	42,45	33,93	7,66
	Teluk Ratai	23,37	47,14	33,96	11,45
	Rawajitu	6,68	22,02	10,84	3,829
PI	Margatiga	12,5	20,85	16,35	2,89
	Teluk Ratai	7,78	16,07	10,97	3,82
	Rawa Jitu	1,23	1,65	1,493	0,131
MDD	Margatiga	1,21	1,53	1,361	0,135
	Teluk Ratai	1,12	1,60	1,424	0,213
	Rawa Jitu	13,95	31,6	21,01	4,697
Wopt	Margatiga	15,75	36,35	28,47	7,747
	Teluk Ratai	17,00	38,00	24,61	9,415
	Rawa Jitu	4,50	17,83	11,71	3,32
CBR	Margatiga	10,90	21,60	14,62	3,70
	Teluk Ratai	14,57	17,23	15,83	1,144

Table 1 shows that the Rawa Jitu area has a high diversity of soil samples containing % Lose No. 200 and moisture content % Lose No. 200 for the Marga Tiga area; and Atterberg Liquid Limit and Atterberg Plastic Limit for Teluk Ratai area. In other words, it can be said that there are gaps in the characteristics of the soil samples for each region.

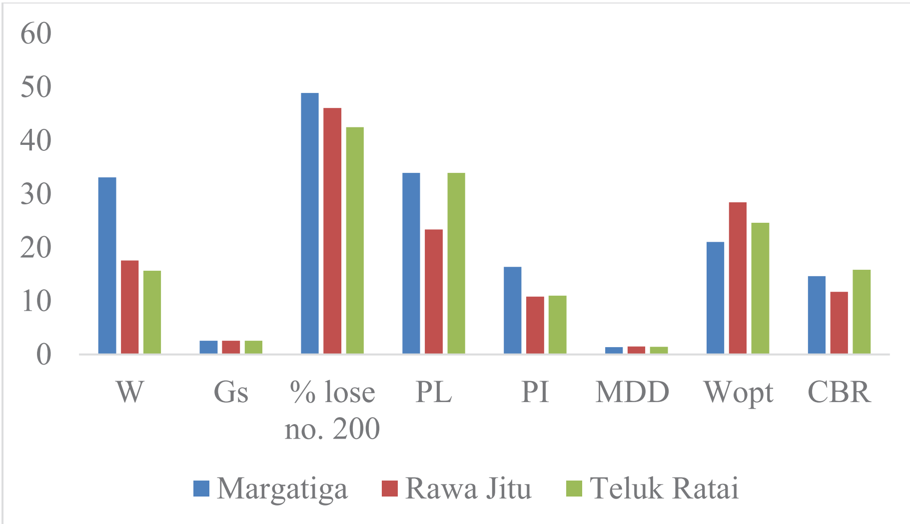

FIGURE 1. Distribution of values of soil characteristics

Table 1 and Fig. 1. show that the three areas where the soil samples were taken have similar soil types. This can be seen from the distribution of parameters for each land location. For example, the value of the CBR value % lose no. 200 is almost the same as the percentage. This means that the land in the province of Lampung has similar characteristics. This can be used if one of the study areas wants to use a sample in another area, it can be used as embankment soil. Moreover, it can be seen that the CBR value is > 6%, the Minimum Standard of Highways, Indonesia. The average color of the soil is sandy loam soil, gray brown color and sandy loam and gravel soil, gray brown color.

Biplot Analysis

The next step in this research is performing biplot analysis. This method is used to obtain a mapping of soil sample characteristics with the measured variables. Based on Figure 2, there are 3 groups of soil samples. Group 1 consisted of soil samples that had the same maximum dry density, CBR value, % Lose No. 200, and the specific weight of the solid granules; group 2 consists of soil samples that have the similar Atterberg Plastic Limit, Atterberg Liquid Limit, and Atterberg Plasticity Index; while group 3 consisted of soil samples that had similar moisture content and optimum moisture content. Based on the diversity of soil sample characteristics, it appears that % Lose No. 200 is the highest diversity and can be said to be a relatively high fine-grained soil characteristic in Rawa Jitu. Based on the relationship between variables, it appears that the water content is positively correlated with the Atterberg Liquid Limit, Atterberg Plasticity Index, and CBR values. This can be explained further that if the water content in the soil sample increases, the Atterberg Liquid Limit, Atterberg Plasticity Index and CBR values will also increase. The increase in the CBR value, in this case, is known to be not proportional to the value of other parameters. This is because the higher the soil water content will reduce the bearing capacity of the soil as shown by the CBR value in Figure 3. CBR value is positively correlated with % Lose No. 200 which indicates that if % Lose No. 200 increases, the CBR value will adapt to the increase in water content. Low water content can also reduce the CBR value. In the Biblop analysis, water content is indicated by a positive correlation. In field conditions, if the water content is low, the CBR value will also be low which indicates that water has an important role as a soil lubricant. The presence of water content, in this case, will make it easier for soil particles to stick to each other so that it will increase the carrying capacity of the soil.

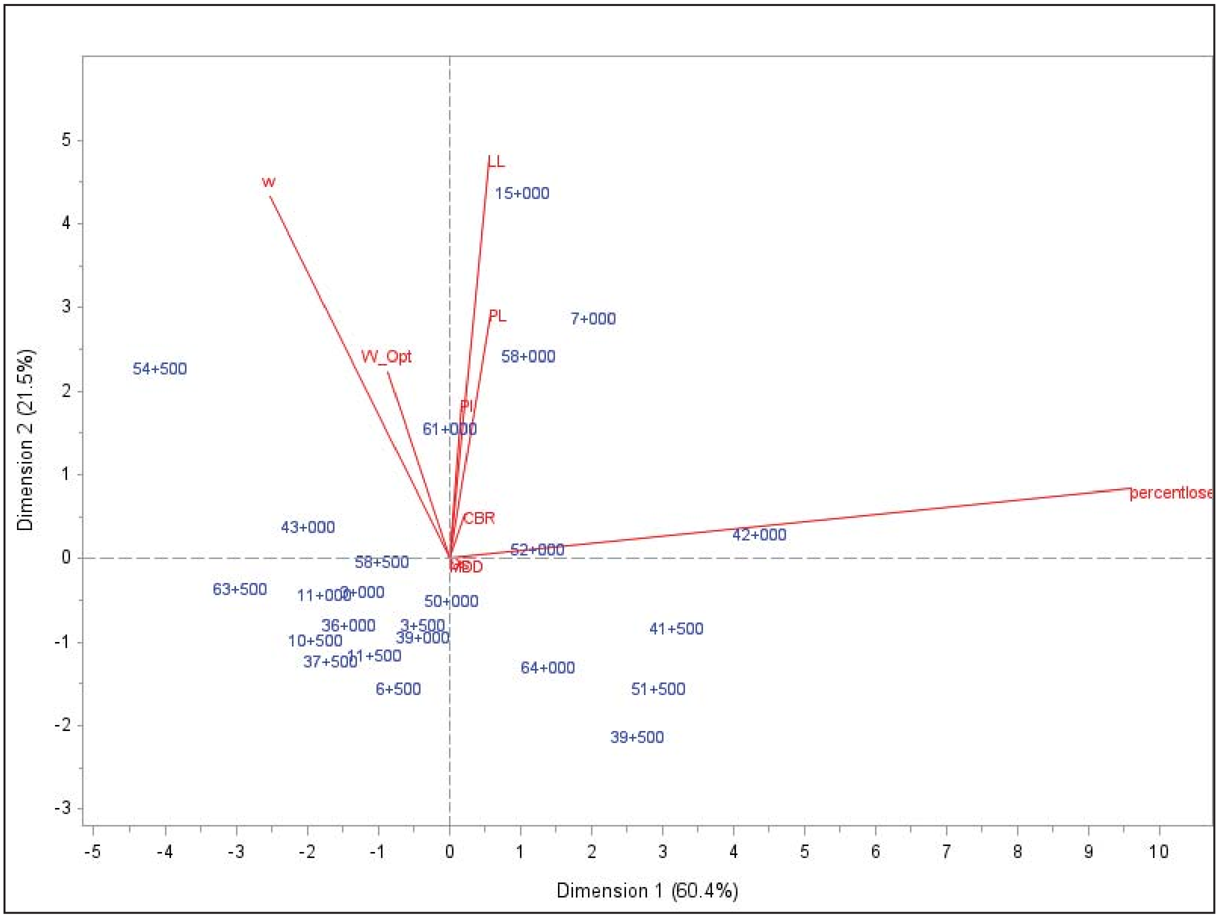

FIGURE 2. Biplot for Rawajitu area

It can be seen that based on Fig. 3. there are 3 groups of soil samples. The first group is group 1 which consists of soil samples that have the same maximum dry density, California bearing ratio; group 2 consists of soil samples that have similar Atterberg Plastic Limit, Atterberg Liquid Limit, moisture content, and optimum moisture content; while group 3 consists of soil samples that have the same % Lose No. 200. Based on the diversity of soil sample characteristics, it appears that % Lose No. 200 is the highest diversity so that it can be said as a relatively high soil characteristic in Margatiga. Based on the relationship between variables, it appears that the water content is positively correlated with the Atterberg Liquid Limit and Atterberg Liquid Limit. This indicates that if the water content in the soil sample increases, the Atterberg Liquid Limit and Atterberg Liquid Limit values will also increase. Meanwhile, California bearing ratio was found to be positively correlated with % Lose No. 200 which means that if % Lose No. 200 increases, then the CBR value will also be affected.

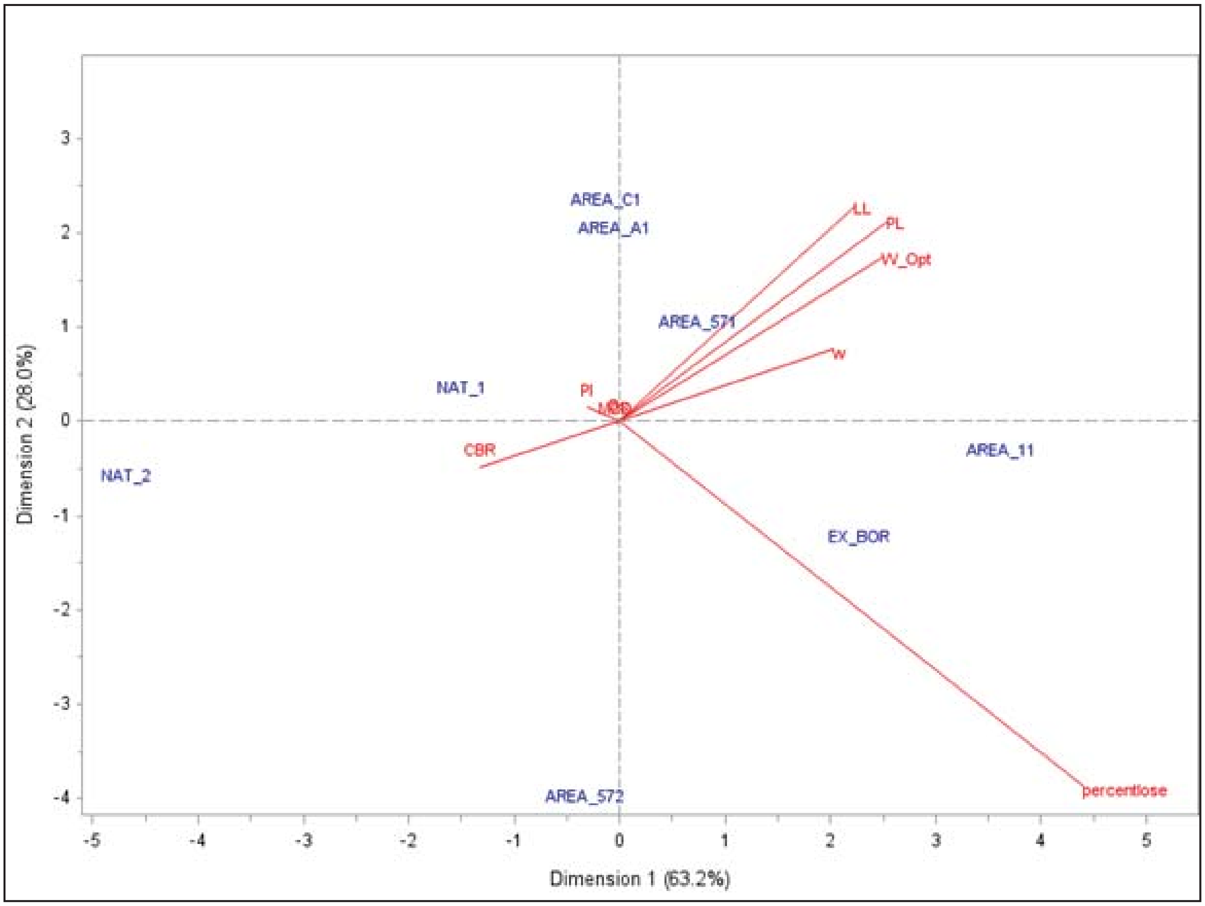

FIGURE 3. Biplot for Margatiga area

Fig. 4. presents 2 groups of soil sample characteristics, namely group 1 consisting of soil samples that have the same maximum dry density, and % Lose No. 200; group 2 consisted of soil samples that had similar values of CBR, Atterberg Plastic Limit, Atterberg Liquid Limit, moisture content, and optimum moisture content. Based on the diversity of soil sample characteristics, it appears that the Atterberg Liquid Limit value is the highest diversity or can be said to be a relatively high soil characteristic in Teluk Ratai. Based on the association between variables, it appears that water content and CBR values are positively correlated with Atterberg Liquid Limit and Atterberg Liquid Limit. This means that if the water content and CBR value in the soil sample increase, the Atterberg Liquid Limit, and Atterberg Liquid Limit values will also increase. It can be interpreted that the value of the carrying capacity of the soil is influenced by the Atterberg Limit value, the percent passing the filter No. 200, and the water content of the soil. Therefore, the execution of experiments in the laboratory and taking soil samples in the field must be done very carefully since they affect each other's values.

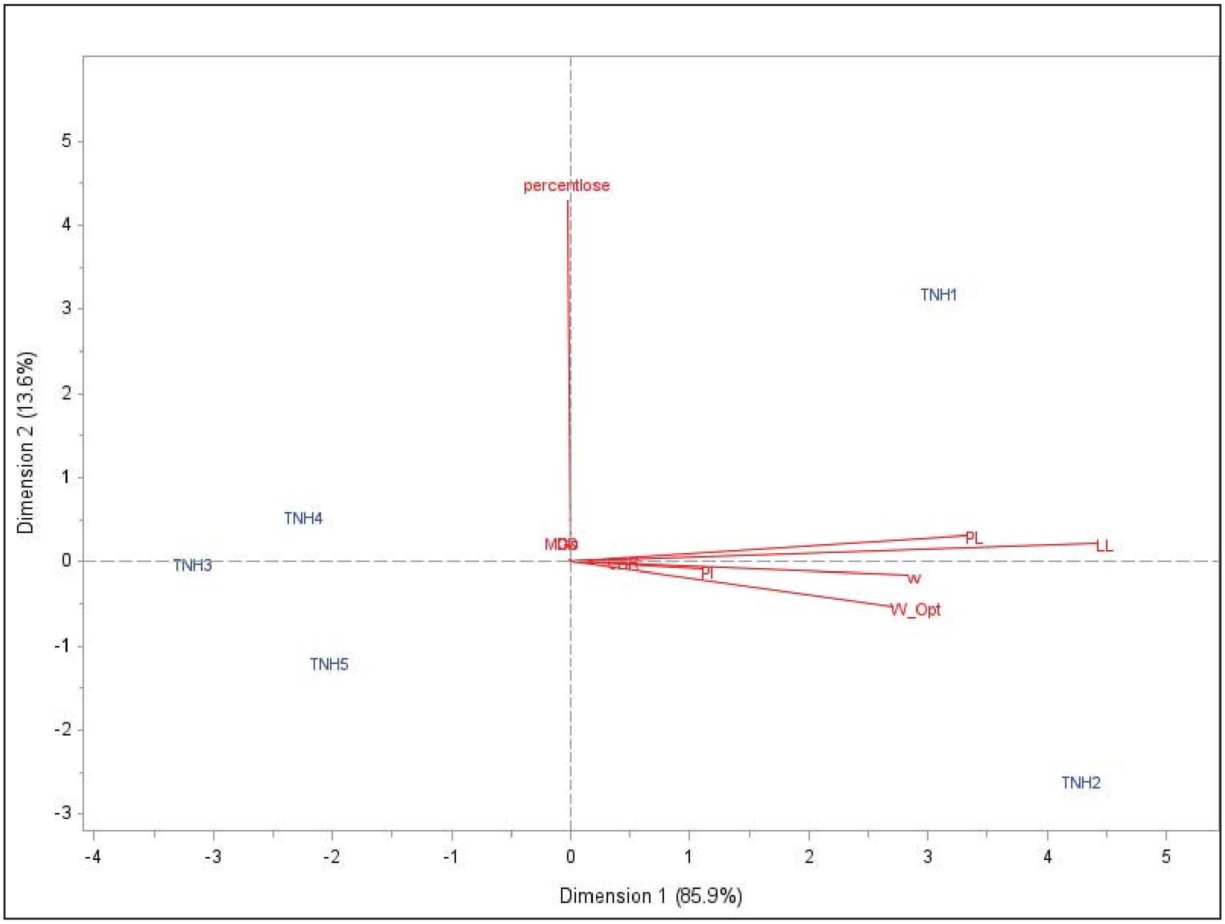

FIGURE 4. Biplot for Teluk Ratai area

CONCLUSION AND SUGGESTION

Knowing the results of the research from biplot analysis, it was concluded that there were 3 groups of soil samples based on the similarity of soil characteristics for the Rawa Jitu and Marga Tiga areas, namely: group 1 consisted of soil samples that had the same maximum dry density, CBR value, and specific weight of solids. ; group 2 consists of soil samples that have the similar Atterberg Plastic Limit, Atterberg Liquid Limit, and Atterberg Plasticity Index; while group 3 consisted of soil samples which had similar moisture content and optimum moisture content, and % Lose No. 200. On the other hand, the Teluk Ratai area has 2 groups of soil samples, including group 1 consisting of soil samples that have the same maximum dry density, and % Lose No. 200, and group 2 consisted of soil samples that had similar soil bearing capacity values tested by laboratory CBR testing, Atterberg Plastic Limit, Atterberg Liquid Limit, moisture content, and optimum moisture content. It is known that based on the diversity of soil sample characteristics, it appears that % Lose No. 200 is the highest diversity so that it can be classified as a relatively high soil characteristic in Margatiga and Rawa Jitu. In the Teluk Ratai region, the highest diversity was found at the Atterberg Liquid Limit. Based on the relationship between variables, it appears that the water content is positively correlated with the Atterberg Liquid Limit and Atterberg Liquid Limit. This indicates that the increase in water content in the soil sample will affect the Atterberg Liquid Limit and Atterberg Liquid Limit values which will also increase. Meanwhile, California bearing ratio was also found to be positively correlated with % Lose No. 200 which indicates that the increase in % Lose No. 200 will affect the CBR value. In this case, the higher the water content, the higher the Atterberg limit value, but it will decrease the CBR value as a result of the high water content where the % Lose will reduce the carrying capacity of the soil. The results of the correlation of soil parameters obtained from laboratory testing to be tested with biblop analysis found that the ideal water content to achieve a good soil bearing capacity value was with a water content value between 21% - 32%, Meanwhile, to get a CBR value between 9% - 13% and the content of fine-grained soil that passes filter no. 200, the criteria for clay content are between 24% - 43%. The requirement for a good subgrade to be used as a road body from the Bina Marga regulation, in this case, is 6%.

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