International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 7 July 2021, pp: 3032-3037 www.ijaem.net ISSN: 2395-5252

Relationship between Relative Density and Land Permeability in Ende Flores Area

Veronika Miana Radja[1)], Faustina Haryanti Viorekta[2)], Indah Wahyuning Tyas[3)]

Civil Engineering, Faculty of Engineering, Flores University, Indonesia
Alumni of Civil Engineering, Faculty of Engineering, Flores University, Indonesia
Civil Engineering, Faculty of Engineering, Flores University, Indonesia

Submitted: 10-07-2021 Revised: 23-07-2021 Accepted: 26-07-2021

ABSTRACT : In project work in the city of Ende Flores, in general, materials taken from excavations are directly used for construction work without carrying out laboratory testing. Therefore, to help users, a study of the maximum soil density in each of these mines was carried out. Furthermore, testing the rate of permeability of the soil after compaction to the maximum.

The samples we used were taken from six different locations including; the land on the coast of Nanganesais land resulting from river deposits, the land at the foot of Mount Ia, TanjungEnde Selatan Village, which is a former volcanic eruption, the land in Wolofeo Village was used for rice fields, the land in Roworeke, Rewarangga Village, is land resulting from river deposits, and the soil at wongge hill.

From the results of the gradation of soil grains, relative density and soil permeability, it can be concluded that the more fine fractions contained in the soil grains, the greater the relative density of the soil but the smaller the permeability of the soil. On the other hand, if there are more coarse fractions contained in the soil grains, the relative density of the soil will be smaller but the permeability of the soil will be greater. The relationship between the value of relative density and soil permeability can be obtained by the equation k = -0.0075 Rd + 0.8273. Where x is the relative density (Rd) and y is the permeability coefficient (k).

Keywords: **S**ilt soil; Permeabilitycoefficient;Relative density;Gradation of soil;Weathering of rocks

I. INTRODUCTION

Soil is the base to support the load of building construction. In order to have a strong bearing capacity, the soil must be in a stable condition, which has a high density level and low water absorption capacity.

Ende Regency is topography in a hilly area, where the soil condition is the result of weathering of hill-forming rocks. So it will be vulnerable when it rains and easily eroded by water. The scoured soil is carried to the bottom of the hill and is used for various purposes, including as a place for residential areas, agricultural land, as well as brick and concrete making material as well as embankment material. Utilization of material as a quarry, of course, must meet several standardized specifications.

The material compacted above the optimum water content presented a superior performance to dissipate pore water pressure along the time than the other soils. Concluding that the use of soil above the optimum can be convenient and economical for dam construction, in the case where no other material is available, and a fast pore water relief is sought, JuliánBuriticáGarcía, et al (2020).

Specification of fine aggregate for mortar and plaster work with cement as the base material must comply with ASSHTO M6-13 and SNI 03-6820-2002 standards and specification of fine aggregate for asphalt pavement mix must comply with ASSHTO M29-12 standard and SNI 03-6819-2002, Binamarga(2018).

A good compaction result is to use a mixture of Ia and Samba sand or Ia and Nananesa sand pasir, Rudu et al (2019)

However, in reality the construction project in Ende City uses materials directly from the existing quarry because it is easy to reach, without testing the quality of materials for concrete work, road foundation work and embankment work. This is because the cost for testing in the laboratory is quite expensive.

Here, the author helps ease the use of material from the quaryespecially simple buildings by looking for the relationship between grain gradation and maximum soil density, as well as

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 7 July 2021, pp: 3032-3037 www.ijaem.net ISSN: 2395-5252

between maximum soil density and soil permeability values. So that material users continue to carry out laboratory tests, at least only the grain gradation test, without conducting compaction and soil permeability tests.

The material compacted above the optimum water content presented a superior performance to dissipate pore water pressure along the time than the other soils.

Therefore, it is necessary to study the maximum density of soil originating from the quary because of the different gradations and constituent materials. Furthermore, testing the rate of permeability of the soil after compaction to the maximum.

II. MATERIAL AND METHODS

The samples we used were taken from six different locations including; the land on the coast of Nanganesais land resulting from river deposits, the land at the foot of Mount Ia, TanjungEnde Selatan Village, which is a former volcanic eruption, the land in Wolofeo Village was used for rice fields, the land in Roworeke, Rewarangga Village, is land resulting from river deposits, and the soil at wonge hill. From the background of soil formation produces different gradations and physical properties of the soil.

One of the requirements as a good embankment material is if it is compacted to reach the maximum density. Where by compacting the soil it will minimize the number of soil pores and increase the shear strength of the soil. So that the bearing capacity of the soil will increase.

The average pore size of the soil which is influenced by the distribution of particle size, particle shape and soil structure will also affect the value of soil permeability. In general, the smaller the particle size, the smaller the pore size and the lower the permeability coefficient.

Therefore, the authors are interested in examining the relationship between the value of maximum soil density and the value of soil permeability after reaching the maximum soil density according to the existing gradation. By getting an equation that states the relationship between the two, it will be easier for users to estimate the value of soil permeability only by obtaining the maximum density value.

III. ANALYSIS AND RESULTS

3.1. Soil properties

At the beginning of earthworks, it is necessary to find out what the properties of the soil that will be used as building construction materials are. In Table 1 we can see the results of the physical properties of the original soil and in Table 2 it is classified according to AASHTO and USCS.

From the results of soil classification analysis in Table 2, it is found that all types of soil from weathering rocks contain silt. Silt soil is a soil that is a transition between clay and sandy soil. Silt is less plastic than clay and has high permeability. Therefore, in its use as a foundation and embankment material, it must be carried out with maximum compaction in order to obtain maximum carrying capacity.

Table 1. Parameters of soil properties

No	Type of Testing	Unit	Unit Location					
			Mount Ia	**Nanganesa**	**Campus**	**Tomberabu**	**Roworeke**	**Wolofeo**
1	**Grain Gradation**							
	Gravel	%	10,82	2,24	4,31	7,82	0,08	0,16
	Sand	%	49,48	54,40	30,85	29,69	5,76	7,89
	Silt	%	25,29	41,00	41,30	38,48	43,10	35,62
	Clay	%	14,41	2,36	23,54	24,01	51,06	56,33
2	**Gravimetry – Volumetry**							
	Specific	gr/cm^3	2,65	2,667	2,64	2,62	2,602	2,584
	Volume	gr/cm^3	1,73	1,49	1,60	1,75	1,11	1,34
3	**Consistency Limits**							
	Liquid Limit	%	21,20	27,50	31,80	24,10	36,40	46,20
	Plastic Limit	%	0,00	0,00	7,50	22,48	28,18	27,27
	Plasticity	%	21,20	27,50	24,30	1,62	8,22	18,93

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 7 July 2021, pp: 3032-3037 www.ijaem.net ISSN: 2395-5252

Table 2. Soil classification to AASHTO and USCS

Location	Classification	
	AASHTO	USCS
Mount Ia	A-2-6 (silty sand)	SM (silty sand)
Nanganesa	A-2-6 (silty sand)	SM (silty sand)
Campus (wongge)	A-2-6 (silty sand)	SM (silty sand)
Tomberabu	A-2-4 (silty sand with	SM (silty sand)
Roworeke	A-4 (silty land)	ML (loamy silt)
Wolofeo	A-7-6 (loamy silt)	ML (loamy silt)

3.2. Relative density

Disturbed soil when sampling is carried out standard compaction testing based on SNI No. 6886: 2012 in order to get the maximum density value (γ_{dmax}) as shown in Figure 1.

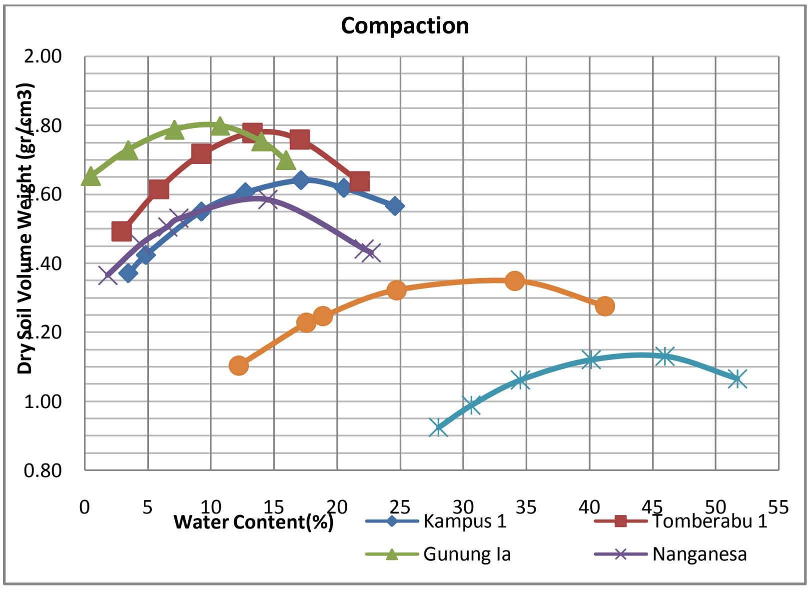

Figure 1. Graph of soil compaction

Figure 1 shows that of the six locations, the densest condition is the sand of Mount Ia with a dry soil volume weight of 1.80 gr/cm^3. The minimum density is obtained by filling the soil in a container without compacting, then the minimum density value (γ_{dmin}) is calculated.

From the maximum (γ_{dmax}) and minimum (γ_{dmin}) density values, the relative density values can be calculated. Relative density is generally used to indicate the level of density of granular soils. Relative density is defined as follows Equation 1.

$$Rd = \frac{\gamma d\ max}{\gamma d} \times \left[\frac{\gamma d - \gamma d\ max}{\gamma d - \gamma d\ min}\right] x \quad 100\% \quad \ldots\ldots (1)$$

Where :

Rd = relative density (%)

γ_{di} = initialdensity (gr/cm^3)

γ_{dmax} = maximum density (gr/cm^3)

γ_{dmin} = minimum density(gr/cm^3)

Table 3 Relative Density of Soil

Relative density	Location					
	Mount	Nangane	Campus	Tomberabu	Rowore	Wolofe
Dry soil density initial	1,73	1,49	1,60	1,75	1,11	1,34
Maximum dry soil density	1,80	1,58	1,64	1,79	1,13	1,35
Minimum dry soil density	1,65	1,37	1,37	1,49	0,92	1,10
Relative Density (Rd) (%)	55,49	60,59	87,31	88,65	92,11	96,72

3.3. Soil permeability

Soil permeability is the ability of the soil to allow water or other fluids to penetrate or seep through its pores.

According to Darcy's Law, the permeability of a soil is determined by its coefficient of permeability. The coefficient of soil permeability depends on several factors including as shown in equation 2.

$$k = \frac{(Q \times L)}{(h \times A \times t)} \qquad (2)$$

Information :

k = permeability coefficient (cm/hour)

Q = Volume of water in a measuring cup (m^3 / s or cm^3 / s)

A = The cross-sectional area of the test object (m^2 or cm^2)

L = Length of specimen / length of flow (m or cm)

h = water level (m or cm)

t = time traveled by water along L (seconds)

i = hydraulic gradient

After the soil compaction test is carried out, the soil that has been compacted is then subjected to a soil permeability test.

1. Falling head test

Conducted for fine-grained soils in order to determine the permeability coefficient of fine-grained soils such as clay. This test is based on SNI No. 2411: 2008.

2. Constant Head Test

Performed for coarse grained soils with a view to.know the permeability coefficient of coarse grained soils such as sand and silt. This test is based on SNI No. 2411: 2008.

Table 4. Soil Permeability after compaction

Location		**k average (cm/hour)**	**Permeablity class**
Roworeke	(Silty land)	0,12	Slow
Wolofeo	(Loamy silt)	0,06	A little slow
Kampus 1	(Silty sand)	0,22	Slow
PantaiNanganesa	(Silty sand)	0,31	Slow
Tomberabu 1	(Silty sand and gravel)	0,39	Moderate
GunungIa	(Silty sand)	0,45	Moderate

From table 4 it can be seen that the samples that have a late permeability coefficient are Wolofeo clay and sandy silt with an average value of 0.06 cm/hour.

3.4. Relationship between grain gradation, relative density and soil permeability

From the test results of each of these soil properties, it can be obtained the relationship between the grain gradation and the relative density value and the relationship between the relative density value and the permeability value.

In Figure 2, it can be seen that when the soil contains a lot of coarse fractions (gravel and sand) of Mount Ia soil, the relative density value (Rd) of the soil decreases, while when the soil contains a lot of fine fractions (silt and clay) the relative density value of the soil increases. This happens because the fine fraction of the soil particles is better at closing the air pores than the coarse fraction. The denser the pores in the soil, the higher the relative density.

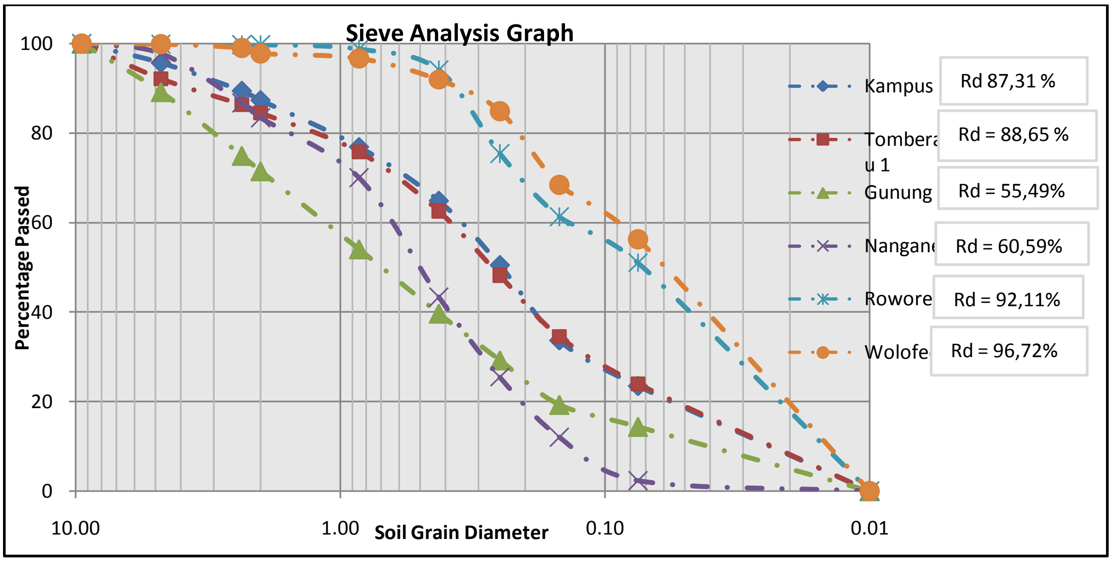

Figure 2. Relationship between gradation and relative density

Table 5. Relationship between Relative Density and Permeability Coefficient

Relative Density	Lokasi					
	GunungI	Nanganesa	Kampus	Tomberabu	Roworek	Wolofe
Dry soil density initial	1,73	1,49	1,60	1,75	1,11	1,34
Maximum dry soil density	1,80	1,58	1,64	1,79	1,13	1,35
Minimum dry soil density	1,65	1,37	1,37	1,49	0,92	1,10
Relative Density (Rc) (%)	55,49	60,59	87,31	88,65	92,11	96,72
Permeability Coefficient	0,45	0,31	0,22	0,19	0,12	0,06

From table 5, it can be seen that when the relative density of Mount Ia sand is 55.49%, the permeability coefficient is 0.45 cm/hour and in the soil originating from Wolofeo, the relative density is 96.72% and the permeability coefficient is 0.06. cm/hour. From this it can be concluded that the value of relative density is inversely proportional to the value of the permeability coefficient. This is more clearly seen in Figure 3.

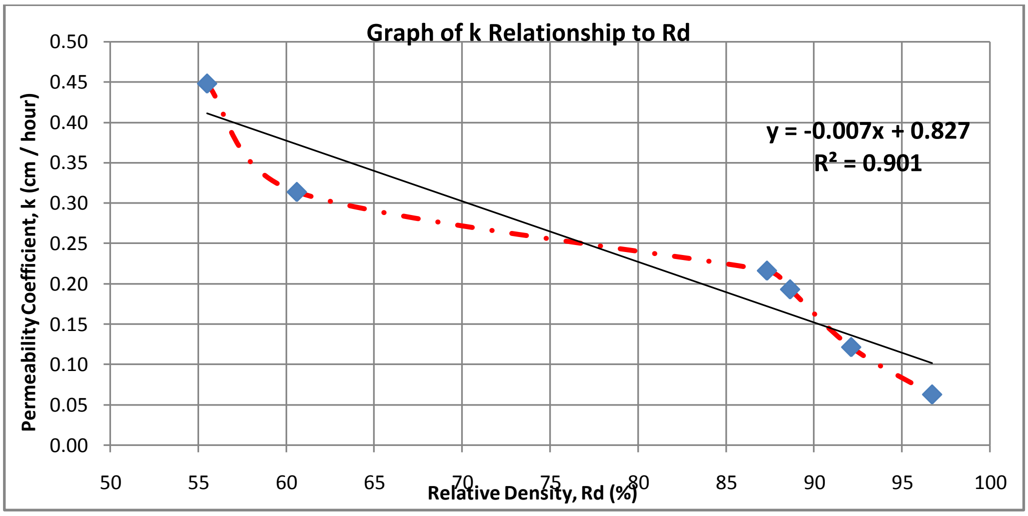

Figure 3. Graph of the relationship between relative density and soil permeability coefficient

Based on Table 5 and Fig 3, it can be concluded that the smaller the permeability coefficient (k) of the soil, the greater the value of the relative density (Rd) of the soil. From the graph above, it can also be obtained a single linear regression equation, namely: y = -0.0075x + 0.8273. Where x is the relative density (Rd) and y is the permeability coefficient (k).

IV. CONCLUSION

From the analysis of soil grain grading, relative density and soil permeability, it can be concluded that if the more fine fractions are contained in the soil grains, the relative soil density is greater but the soil permeability is getting smaller. on the other hand, if the more coarse fraction is contained in the soil grains, the relative density of the soil is getting smaller but the permeability of the soil is getting bigger. The relationship between the value of relative density and soil permeability can be obtained by the equation k = -0.0075 Rd + 0.8273. Where x is the relative density (Rd) and y is the permeability coefficient (k).

REFERENCES

[1]. Bell, 2017, "Compaction Energy Relationships of Cohesive Soils",Department of Civil Engineering", Oregon State University, http://onlinepubs.trb.org/Onlinepubs/trr/1977/641/641-006

Binamarga, 2018, SpesifikasiUmumJalandanJembatan, Jakarta, Indonesia, https://binamarga.pu.go.id

[3]. Bowles, Joseph E. 1991. Sifat-sifatFisisdanGeoteknis Tanah (Mekanika Tanah).Jakarta :Erlangga, Indonesia

[4]. Darwis. 2018. Dasar – DasarMekanika Tanah. Jogjakarta : Pena Idris .

Das, Braja M. 1995. Mekanika Tanah Jilid I. Jakarta :Erlangga, https://perpushms.files.wordpress.com

Fatwa, 2017,"Metode PengujianKepadatan Tanah Dengan Proctor Test", Baturisit, https://baturisit.blogspot.com › search › label › Proctor

[7]. Julián Buriticá García André Pacheco de Assis Juan P. Villacreses, 2020, "Bhavioral evaluation of earth dams built with materials above optimum moisture content in high rainfall areas", Soil and rocks journal Vol 43,https://serdigital.com.br/temp/soilsandrocks/article/1727DOI: 10.28927/SR.434591

[8]. Larasati, Diah. 2016. "UjiKuatTekan Paving Block MenggunakanCampuran Tanah danKapurMenggunakanAlatPemadatModifikasi".Universitas Lampung. Bandar Lampung.

[9]. NN. 2017. "BukuPanduanPraktikumMekanika Tanah", Universitas Indonesia, https://www.coursehero.com/file/30248592/BUKU-PANDUAN-PRAKTIKUM-MEKANIKA-TANAH-2017pdf/

[10]. NN, 2008, "Soil Quality Indicators", USDA, NRCS, DOI **https://doi.org/10.2134/agronj2002.3300**

[11]. PemkabEnde, 2017, "RKPD KabupatenEndeTahun 2018", Ende NTT, https://portal.endekab.go.id/images/TRANSPARANSI/RKPD2018

Rudu, Radja, Suku, 2019, "AnalisisNilaiKepadatan Tanah Quarry Ia, Samba, NanganesadanWokonio", JurnalTeknosiar Volume 13 No 2 tahun 2019, http://e-journal.uniflor.ac.id/index.php/TEKNOSIAR/article/view/234 DOI: https://doi.org/10.37478/teknosiar.v13i2.234Sembiring, Natanael, dkk. 2016. "StudiPerbandinganUjiPemadatan Standard danUjiPemadatan Modified TerhadapNilaiKoefisienPermeabilitas Tanah LempungBerpasir" dalamJurnal TRSDD. No 3 Volume 4 Tahun 2016.https://www.neliti.com › publications

[13]. Syahputra, 2016,"Analisis PerbandinganKepadatanNilai Modified Proctor Dan Standard Proctor Di LaboratoriumDenganKepadatanNilai Sand Cone Di Lapangan", Electronic Thesis and Dissertations Unsyiah, https://etd.unsyiah.ac.id/baca/index.php?id=24988&page=1

[14]. Yusoff, 2017,"The Effects of different compaction energy on geotechnical properties of Kaolin and Laterite", AIP Conference Proceedings 1875, https://aip.scitation.org/doi/pdf/10.1063/1.4998380