# Correlation of Soil Density Test with Direct Shear Test on Soil Mixture of Ex Kudus Ring Road and Sand at Guamanik Beach, Jepara

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**Abstract -** Soil has a very important role in construction, because the soil is used as a support for the load above it. The method used in research is a mindset used by researchers about how research continues to run. From the testing data on physical properties and engineering properties that have been tested on original soil samples with the addition of Jepara Guamanik Beach sand, the soil testing on the Kudus Ring Road has different levels and characteristics. The following is the best value for the percentage of sand mixture, in the specific gravity (gs) test, which is 5% with a value of 2.576, the Atteberg limit test on the plasticity index has the lowest value with the addition of 20% sand with a value of 0.57, the proctormodified test has the highest optimum content value. with the addition of 20% sand using 30 impacts with a value of 26.5, while the unit weight value of dry soil was 1.399, in the direct shear test the highest cohesion value occurred with the addition of 5% sand using 60 impacts with a value of 0.823, while the internal shear angle value was 23.97.

**Keywords** : *Soil, Proctor modified, direct Shear Test*

## INTRODUCTION

Soil is the basis of construction. Soil has a very important role in construction, because the soil is used as a support for the load above which will later build a building. Soil bearing strength is a soil parameter relating to the strength of the soil to support a load on it. The strength of the soil support is influenced by the amount of air contained in it, cohesion, internal friction angle, and normal stress on the soil.

Soil is a material consisting of solid aggregates (grains) cemented to each other and from weathered organic materials accompanied by liquid and gas which fill the empty spaces between the solid particles (Braja M Das, 1988) . Soil sediments can combine into clay and silt soil grains. Both types of soil granules have high water content and loose sand content located near or below the ground water level.

Clay is mineral particles smaller than 0.002 mm. These particles are the main source of cohesion in cohesive soil (Bowles, 1991). Clay soil is very hard when dry and plastic at moderate water content. Silt is rock particles ranging in size from 0.002 mm to 0.074 mm. Large amounts of silt and

clay are found in deposits sedimented into lakes or near the coastline at river mouths (Riadi, 2021). At higher air levels, clay is sticky and very soft (Das, 1998).

Sedimentary soil that will be used as base soil for road pavement construction must be repaired first. According to (Holtz and Kovacs 1981), sedimentary soil can be defined as soil that has the majority of very fine grain sizes (passing sieve No. 200). From the results of observations that researchers have made, on the Kudus Ring Road there are many signs of potholes and the result is uneven ground splits and cracks in the road due to unstable land subsidence. One of the factors causing signs of waves and cracks on the road is that most of the area has soil types that have low levels of compressive and shear strength. Based on the condition of the land, efforts need to be made to improve it so that it is not dangerous and so that there are no losses in development. In this research, soil stabilization used additional materials originating from the sand of Guamanik Beach, Jepara.

Optimization of soil sediment needs to be carried out to obtain the planned soil properties and have good soil carrying capacity, so that the soil that has been optimized by mixing the Kudus Ring Road soil with the Jepara Guamanic Beach sand gets the appropriate value. In this test, a Soil Compaction Test is carried out with the aim of increasing the strength of the soil, reducing the influence of air on the soil, reducing its compressibility and water seepage capacity, and in this test the aim is to determine the relationship between air content and soil density. Meanwhile, the Direct Shear Test is a direct shear test to obtain the shear strength of the soil.

## METHODS

This research approach was carried out to obtain results from the experiment of adding Jepara Guamanik Beach Sand to the former Kudus Ring Road Land. By conducting this research, it can be evaluated how the results of mixing the Jepara Guamanik Beach Sand and the land from the former Kudus Ring Road will be. According to (Jaedun, 2011), experimental research is a type of research used to find out what factors are and how they relate to one another.

This research was carried out at the Civil Engineering Laboratory, Campus 3, Universitas PGRI Semarang. Soil sampling was on the Kudus Ring Road, while sand sampling was at Guamanik Beach, Jepara. The sampling method is by taking soil to a depth of ±50 cm, because the soil at that depth is still original and has not been mixed with different soils. Then, the sand sample is taken by digging with a simple tool using a hoe and then putting it into a sack. The number of test samples that will be carried out can be seen in the following table:

**Table 1.** Types of Testing and Number of Samples

| Variasi Campuran Tanah | Testing | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Physical Propertis | | | | | | Engineering Propeties | |
| | Water content | Density | liquid limit test | Plastis limit | Gradation | Analiysis Hydrometer | Proctor Modified | Direct Shear |
| Tanah Asli | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 |
| Pasir Pantai | 3 | 3 | - | - | 3 | - | - | - |
| Tanah Asli + 5% Pasir | - | 3 | 3 | 3 | - | - | 2 | 2 |
| Tanah Asli + 10% Pasir | - | 3 | 3 | 3 | - | - | 2 | 2 |
| Tanah Asli + 15% Pasir | - | 3 | 3 | 3 | - | - | 2 | 2 |
| Tanah Asli + 20% Pasir | - | 3 | 3 | 3 | - | - | 2 | 2 |
| Jumlah | 6 | 18 | 15 | 15 | 6 | 3 | 11 | 10 |
| **Jumlah Total** | **84** | | | | | | | |

The research process is a process or stages that must be passed in a research so that the results obtained are systematic and can be scientifically justified. After the soil samples were ready, as explained in table 1, the researchers carried out 2 tests where the test material would be tested, testing the original soil and beach sand in accordance with the specified regulations. The steps for testing

original soil are: (1) testing water content; (2) soil specific gravity testing; (3) liquid limit testing; (4) fine grain sieve analysis; (5) hydrometer analysis testing; (6) soil compaction testing; (7) and direct shear testing.

The aim of this research is to analyze the physical and mechanical properties of the Kudus Circle soil samples, then analyze the physical properties, and evaluate the effect of mixing Jepara Guamanic beach sand on compressive and shear strength. The data collection techniques used are taking soil samples, testing and documentation. In carrying out research on soil density tests using direct shear tests on the Kudus Ring Road soil mixture with the addition of Guamanik Jepara Beach Sand, a research design was carried out so that in carrying out the research the flow that would be carried out could be understood, such as the processes and methods in carrying out the research could be carried out using easy. The flow of research methods in this research can be seen in the following chart:

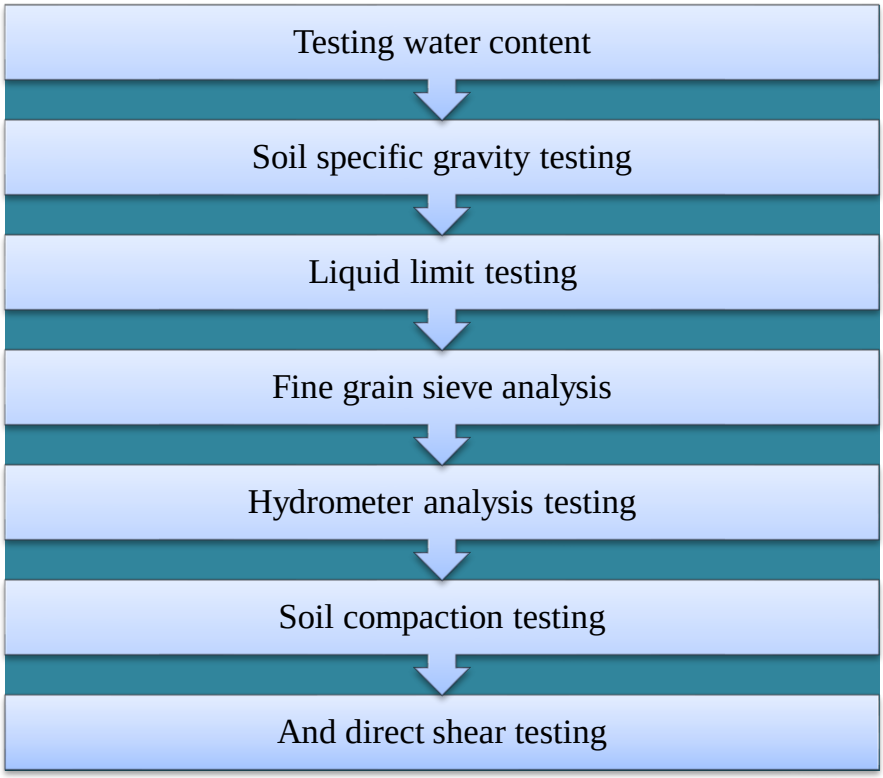


**Figure 1.** Flow chart of soil density testing

## RESULTS AND DICUSSION

Based on research on the relationship between soil density tests and direct shear tests on a mixture of soil from the former Kudus Ring Road with sand from Guamanik Beach in Jepara for taking soil samples to a depth of ±50 cm from the ground surface which was carried out at the Civil Engineering Laboratory, Campus 3, Universitas PGRI Semarang. When researchers carry out research or experiments that are going well, the researchers form a work flow chart with the aim of describing a research implementation so that it is explained clearly and can be seen in Figure 1. The original soil density testing data is as follows:

### Water Content Testing Data

Water content testing aims to determine the water content in the soil which is presented in Table 2.

**Table 2.** Testing of original soil water content

| No | | Sample | | |
|---|---|---|---|---|
| 1 | Berat Cawan (gr) | 11,5 | 10,7 | 10,7 |
| 2 | Berat Tanah Basah + Cawan (gr) | 46,0 | 47,7 | 45,5 |

| | | | | |
|---|---|---|---|---|
| 3 | Berat Tanah Kering + Cawan (gr) | 39,0 | 40,5 | 38,6 |
| 4 | Berat Air (gr) | 7 | 7,2 | 6,9 |
| 5 | Berat Tanah Kering (gr) | 27,5 | 29,8 | 27,9 |
| 6 | Kadar Air (%) | 25,454 | 24,161 | 24,731 |
| 7 | Rata-rata (%) | | 24,78 | |

**Soil Specific Gravity Test Data**

Soil specific gravity tests were carried out on soil samples three times and the averages were presented in table 3.

**Table 3.** Soil Specific Gravity Test

| Sampel | 1 | 2 | 3 | rata rata |
|---|---|---|---|---|
| berat piknometer kosong (a) | 73,2 | 73,7 | 74,8 | 73,9 |
| berat piknometer + aquades (b) | 178,5 | 178,7 | 179 | 178,7 |
| berat piknometer + sampel kering (c) | 98,3 | 98,5 | 98,9 | 98,6 |
| berat piknometer +sampel +aquades (d) | 193,7667 | 193,9 | 193,5 | 193,7 |
| temperature b (t1) | 28 | 28 | 28 | 28 |
| tmperaturen d (t2) | 29 | 29 | 29 | 29 |
| faktor koreksi suhu (T1) | 1,00374 | 1,00374 | 1,00374 | 1,00374 |
| faktor koreksi suhu (T2) | 1,00400 | 1,00400 | 1,00400 | 1,00400 |
| berat jenis butir tanah (Gs) | 2,555 | 2,575 | 2,513 | 2,547 |

**Liquid Limit Test Data**

Atterberg Limit testing consists of two types of testing, namely liquid limit and plastic limit testing and to determine the plasticity index. The Atterberg Limit test results are presented in table 4.

**Table 4.** Liquid Limit Testing

| | BATAS CAIR (LL) | | | | BATAS PLASTIS (PL) | | |
|---|---|---|---|---|---|---|---|
| BANYAKNYA PUKULAN | 17 | 22 | 32 | 35 | | | |
| NOMOR CAWAN | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| BERAT CAWAN | 11,40 | 10,60 | 10,50 | 10,70 | 10,70 | 11,40 | 10,80 |
| BRT. CAWAN + TNH. BASAH | 47,28 | 47,33 | 48,85 | 48,56 | 24,54 | 24,81 | 24,15 |
| BRT. CAWAN + TNH. KERING | 38,12 | 38,24 | 40,28 | 40,68 | 21,97 | 22,14 | 21,35 |
| BERAT AIR | 9,16 | 9,09 | 8,57 | 7,88 | 2,57 | 2,67 | 2,80 |
| BERAT TANAH KERING | 26,72 | 27,64 | 29,78 | 29,98 | 11,27 | 10,74 | 10,55 |
| KADAR AIR (%) | 34,28 | 32,89 | 28,78 | 26,28 | 22,80 | 24,86 | 26,54 |
| | | | | | 24,73 | | |

| | |
|---|---|
| LL (%) | 31,20 |
| PL (%) | 24,73 |
| PI (%) | 6,47 |

**Fine Grain Sifter Analysis Data**

Soil grain analysis testing aims to determine the grain content contained in the original sedimentary soil. Soil grain analysis experiments were carried out three times on test samples and presented in the form of table 5 which has been averaged.

**Table 5.** Fine Grain Sifter Analysis Data

| Saringan | | brt mtrl terthn diatas saringan | % tertahan tiap saringan | % komulatif tertahan | % lolos |
|---|---|---|---|---|---|
| Nomor | Diameter | | | | |
| 4 | 4,75 | 29,0 | 2,90 | 2,90 | 97,10 |

| | | | | | |
|---|---|---|---|---|---|
| 8 | 2,36 | 28,8 | 2,88 | 5,78 | 94,22 |
| 10 | 2,00 | 14,7 | 1,47 | 7,25 | 92,75 |
| 30 | 0,60 | 52,2 | 5,22 | 12,47 | 87,53 |
| 50 | 0,30 | 30,8 | 3,08 | 15,55 | 84,45 |
| 100 | 0,15 | 96,5 | 9,65 | 25,20 | 74,80 |
| 200 | 0,075 | 68,1 | 6,81 | 32,00 | 68,00 |

**Hydrometer Analysis Test Data**

Hydrometer analysis is a method for calculating the distribution of soil grain sizes based on soil sedimentation in water, sometimes also called a sedimentation test. This analysis aims to determine the grain size distribution of fine-grained soil as described in table 6.

**Table 6.** Hydrometer Analysis Test

| Waktu | Suhu | Pembacaan Hidrometer | Nilai Faktor A | Diameter (mm) | Koreksi Suhu Bahan Dispersi | Pembcaan Terkoreksi | Nilai Koreksi Berat Jenis | Presentase Mengendap | Presentase Lolos Terhadap Seluruh Material |
|---|---|---|---|---|---|---|---|---|---|
| (menit) | ($^0$C) | (RH) | | (D) | (k) | (RH+k) | (a) | (%) | (%) |
| 0 | 27 | 60 | 0,0130 | 0,075 | 2,0 | 62,0 | 1,02 | 63,24 | 68,00 |
| 0,5 | 27 | 50 | 0,0130 | 0,052324 | 2,0 | 52,0 | 1,02 | 53,04 | 36,0672 |
| 1 | 27 | 44 | 0,0130 | 0,039216 | 2,0 | 46,0 | 1,02 | 46,92 | 31,9056 |
| 2 | 27 | 38 | 0,0130 | 0,029214 | 2,0 | 40,0 | 1,02 | 40,8 | 27,744 |
| 5 | 27 | 30 | 0,0130 | 0,019630 | 2,0 | 32,0 | 1,02 | 32,64 | 22,1952 |
| 15 | 27 | 20 | 0,0130 | 0,012102 | 2,0 | 22,0 | 1,02 | 22,44 | 15,2592 |
| 30 | 28 | 16 | 0,0128 | 0,008650 | 2,4 | 18,4 | 1,02 | 18,768 | 12,76224 |
| 60 | 28 | 12 | 0,0128 | 0,006249 | 2,4 | 14,4 | 1,02 | 14,688 | 9,98784 |
| 240 | 29 | 9 | 0,0126 | 0,003129 | 2,8 | 11,8 | 1,02 | 12,036 | 8,18448 |
| 1440 | 29 | 0 | 0,0126 | 0,001341 | 2,8 | 2,8 | 1,02 | 2,856 | 1,94208 |

**Soil Compaction Test Data (Proctor Modified)**

This soil compaction test aims to increase the strength of the soil by compacting it so that the voids in the soil sample can be reduced, resulting in better soil density. This is done by pounding the soil with a load of 30 times, 56 times, and 60 times and adding five layers of soil into the mold, then the optimum water content value and maximum dry unit weight value are obtained. For table 7 below, the original soil compaction test was carried out with 56 impacts.

**Table 7.** Soil Compaction Test

| | | | | | |
|---|---|---|---|---|---|
| Berat Tanah | 2000 | 2000 | 2000 | 2000 | 2000 |
| Penambahan Air | 100 | 200 | 300 | 400 | 500 |
| BERAT ISI | | | | | |
| Berat Cetakan (gr) | 3.920 | 3.920 | 3.920 | 3.920 | 3.920 |
| Berat Tanah Basah + Cetakan (gr) | 5.470 | 5.535 | 5.635 | 5.690 | 5.540 |
| Berat Tanah Basah (gr) | 1.550 | 1.615 | 1.715 | 1.770 | 1.620 |
| Isi Cetakan (cc) | 959,8 | 959,8 | 959,8 | 959,8 | 959,8 |
| Berat Isi Tanah Basah (gr/cc) | 1,615 | 1,683 | 1,787 | 1,844 | 1,688 |
| Berat Isi Tanah Kering (gr/cc) | 1,440 | 1,419 | 1,440 | 1,388 | 1,169 |
| KADAR AIR (%) | | | | | |
| Berat Cawan (gr) | 19 | 19 | 19 | 19 | 19 |
| Berat Tanah Basah + Cawan (gr) | 55,9 | 67,5 | 59,7 | 74,8 | 86,3 |
| Berat Tanah Kering + Cawan (gr) | 51,9 | 59,9 | 51,8 | 61 | 65,6 |
| Berat Air (gr) | 4 | 7,6 | 7,9 | 13,8 | 20,7 |
| Berat Tanah Kering (gr) | 32,9 | 40,9 | 32,8 | 42 | 46,6 |
| Kadar Air (%) | 12,158 | 18,582 | 24,085 | 32,857 | 44,421 |

**Direct Shear Test Data.**

The results of direct shear testing on real soil samples are presented in the table below. Then a calculation analysis is carried out to determine the cohesion value (c) and internal friction angle (ϕ) which are presented in table 8.

**Table 8.** Direct Shear Testing.

| | | |
|---|---|---|
| Diameter cetakan | 6,29 | cm |
| Tinggi cetakan | 2 | cm |
| Luas Permukaan | 31,06 | $cm^2$ |
| Kalibrasi Proving Ring | 0,48 | kg/div |
| Jenis Sampel | | |

| No. Test | I | | | II | | | III | | |
|---|---|---|---|---|---|---|---|---|---|
| Gaya Normal | P1 = | 3,168 | kg | P2 = | 6,336 | kg | P3 = | 12,672 | kg |
| Tegangan Normal | σ1 = | 0,1020 | $kg/cm^2$ | σ2 = | 0,2040 | $kg/cm^2$ | σ3 = | 0,4080 | $kg/cm^2$ |

| No. Test | I | II | III |
|---|---|---|---|
| Bacaan dial maksimum | 27 | 56 | 72 |
| Gaya Geser (kg) | 12,96 | 26,88 | 34,56 |
| Tegangan Geser ($kg/cm^2$) | 0,417 | 0,865 | 1,113 |
| Tegangan Normal ($kg/cm^2$) | 0,102 | 0,204 | 0,408 |

Cohesion (c) = 0.294 kg/cm2
Internal friction angle (θ) = 32.37º

## CONCLUSION

Based on the results of research conducted on soil from the Kudus Ring Road, it shows that the soil is sandy silt with a water content of 24.78%. The soil of the Kudus Ring Road has a specific gravity (Gs) of 2.547 and a plasticity index of 7.70. Meanwhile, the optimum water content from the soil compaction test using 56 impacts was 18.8%, 56 impacts was 1,440 gr/cc. Meanwhile, the cohesion value of the direct shear test using 56 impacts was 0.309 kg/cm, with the shear angle value using the shear angle value in 56 impacts of 32.53º.

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**REFERENCES**

Bowles, J.E. (1989). Soil Physical and Geotechnical Properties. Erlangga. Jakarta.

Bowles, J. E. (1993). Physical and geotechnical properties of soil (Soil Mechanics). Hainim Translation. J.K, Jakarta: Erlangga.

Budirahardjo, S. Soil Testing Practical Instructions, Civil Engineering, PGRI University Semarang.

Das, B. M. (1988). Soil Mechanics Volume I. Jakarta: Erlangga.

Das, B. M. (1991). Soil Mechanics, Principles of Geotechnical Engineering volume I. Jakarta: Erlangga.

Das, Braja, M., (1998). Soil Mechanics (Principles of Geotechnical Engineering). Volume-1, Erlangga, Jakarta.

Fahman, D, et al., (2021). Correlation of Unconfined Compressive Strength and Shear Strength in Soft Soil Modified with Varying Sand Mixtures in Pontianak City. Civil Engineering, Faculty of Engineering, Tanjungpura University, Pontianak, Pontianak

Holtz, Kovacs. (1981). Journal of Minerals and Materials Characterization and Engineering. https://www.scirp.org/reference/ReferencesPapers?ReferenceID=1888996

Hary Christiady Hardiyatmo, (1992). Soil Mechanics 1 and Soil Mechanics 2, Gramedia Pustaka Utama, Jakarta.

Nugroho, S.A, et al., (2011). Correlation of Shear Strength Parameters from Direct Shear Test Results and Triaxial Tests on Sand-Clay Soil Mixtures. Journal of Science and Technology10 Faculty of Engineering, University of Riau, Pekanbaru.

Sudarman, A. R, et al., (2016). Correlation between Unconfined Compressive Strength and Direct Shear Compressive Strength in Silt Soil Substituted with Sand. Civil Engineering, Faculty of Engineering, University of Lampung, Lampung.