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The Effect of Adding Bamboo Leaf Ash and Cement on the Stability of Clay Soil

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ABSTRACT: Subgrade soil or clay subgrade is a type of soil with very high pore water characteristics, causing problems for civil structures, both buildings and road pavements. Bamboo leaf ash contains several compounds such as silica (SiO_2) at 77.24%, while cement contains several calcium oxide (CaO) compounds at 60%. Bamboo leaf ash has a high silica content which functions as a support for pozzolanic reactions with clay soil. The variations in the mixture of bamboo leaf ash and cement used are 2%, 3%, 4%, 5% and 6% for bamboo leaf ash and 20% for cement by weight of soil, with a curing time of 4 days. From the two tests that have been carried out, namely soil compaction (Standard Proctor) and Unsoaked CBR (California Bearing Ratio), the optimum values obtained for soil compaction (Standard Proctor) and CBR (California Bearing Ratio) Unsoaked are in the variation of soil + cement addition of 20% + Bamboo Leaf Ash 3%. In the soil compaction test (Standard Proctor), the dry volume weight value was 1,728 gr/cm3 and the optimum water content value was 16.02%, while in the Unsoaked CBR (California Bearing Ratio) the optimum CBR percentage value was 10.25%.

KEYWORDS: Clay, Stabilization, Bamboo Leaf Ash, Cement.

INTRODUCTION

Subgrade soil or clay subgrade is a type of soil with very high pore water characteristics, causing problems for civil structures, both buildings and road pavements. In a construction site, the soil always has an important role in it because the soil is the foundation that supports the construction above it. Soil that has low bearing capacity will result in unstable soil conditions and damage to the road surface. Damage to road construction often occurs before it reaches its planned service life. Various types of damage that occur include cracks on the road surface, holes, bumps and patches due to repeated excavations.

Clay is a type of soil that is spread throughout most of Indonesia, but this soil has several detrimental properties, one of which is the expansive nature of clay. This property has a relatively low bearing capacity when saturated with water, the potential for shrinkage expansion, and high plasticity (Chen, 1975). Soil stability can be done using chemical methods. Chemical stability is a stability method using added materials processed in certain proportions to improve the technical properties of the soil. This mixture was chosen because the ash content of bamboo leaves contains several compounds such as the element silica (SiO_2) of 75.90%. (Olubenga O. Amu. Et al., 2010). Meanwhile, cement contains 60% calcium oxide (CaO) compounds. Bamboo leaf ash has a high silica content which functions as a supporter of pozzolanic reactions with clay soil. Meanwhile, cement contains quite a lot of calcium oxide which, when mixed with clay minerals, reacts to form calcium silicate in the form of a hard gel to increase the stability of soil particles. This silica gel coats and binds clay particles and covers soil pores.

The aim of this research is to determine the percentage variation in adding bamboo leaf ash and cement, to achieve optimal clay soil stability values.

LITERATURE REVIEW SOIL

Civil engineers divide the materials that make up the earth's crust into two types, namely soil and rock. Soil forms in layers due to physical, chemical and biological processes which include the transformation of soil materials. Soil is a collection of natural mineral grains (aggregates) which can be separated by mechanical means when the aggregates are stirred in water. Meanwhile, rocks are aggregates whose minerals are bound together by permanent and strong cohesive forces, and cannot be separated by simple mechanical means. Meanwhile, according to agricultural experts, what is meant by soil is a natural medium in which plants and crops grow which are composed of solid, gas and liquid materials. The terms sand, clay, silt and mud are used to describe particle sizes within predetermined grain size limits, as well as being used to describe the physical properties of soil.

CLAY

Clay soil is soil with microconic to sub-microconic sizes which originates from the weathering of the chemical elements that make up rocks. Clay soil is very hard when dry, and is not easily peeled off with just your fingers. The permeability of clay is very low, it is plastic at moderate water content. In general soil classification, clay particles have a diameter of 2 µm or around 0.002 mm (USDA, AASHTO, USCS). However, in some cases particles measuring between 0.002 mm to 0.005 mm are still classified as clay particles (ASTM-D-653).

SOIL STABILIZATION

Soil stabilization is an effort to technically improve soil properties by using certain materials. This work is generally carried out by mixing the soil with other types of soil so that the desired gradation can be obtained. Apart from that, soil mixing can also be done using factory-made materials so that the technical properties of the soil can be better. Soil stabilization usually has the main aim of changing the technical properties of the soil itself, such as compressibility, bearing capacity, ease of work, permeability, sensitivity to changing water content, and development potential.

Soil stabilization work in the construction process in the form of road paving, is a form of soil stabilization that is commonly carried out in society. This work aims to improve the material on local roads by using mechanical stabilization methods or adding additional materials to the soil. Of course, road pavement plans must also go through a design process first. Each layer of material to be used in road pavement must also meet good quality requirements.

BAMBOO LEAF ASH

Bamboo leaf ash is the result of burning bamboo leaf waste which is obtained from two burning processes, namely open burning and closed burning. In open burning, bamboo leaves are burned until they become blackish powder, then closed burning is carried out in a closed oven until the blackish powder turns white (Wijaya et al, 2020). In relation to soil stability, bamboo leaf ash is a pozzolanic material that can be used as a partial replacement for cement because it has pozzolanic properties. This pozzolanic property is formed due to the reaction process between SiO_2, Al_2O_3 with water and lime which will form hydrated cementitious calcium silicate and calcium aluminate hydrate in the form of a segmented gel which functions to bind soil particles so that they do not dissolve easily in water (Basudewa, 1997).

CEMENT

Cement comes from the Latin caementum which means adhesive material. In simple terms, the definition of cement is even an adhesive or glue that can stick together other materials such as bricks and coral to form a building. Meanwhile, in general terms, it is defined as an adhesive material which has the property of being able to bind solid materials into one compact and strong unit (Bonardo Pangaribuan, 2020). Cement is one of the most important building materials, this material is used to bind other building materials together.

Based on the Indonesian national standard (SNI) number 15-2049-2004, portland cement is hydraulic cement produced by grinding portland slag (clinker), especially which consists of calcium silicate (CaO, SiO_2) which is hydraulic and is ground together with other materials. additionally in the form of one or more crystalline forms of calcium silicate compounds ($CaO.SiO_2$) and calcium sulfate ($CaSO_4,H_2O$) which are hydraulic and react very quickly with water. The reaction of cement and water takes place irreversibly, meaning it can only happen once and cannot return to its original condition.

SOIL CLASSIFICATION

Soil classification is a science that deals with the categorization of soil based on the characteristics that differentiate each type of soil. Soil classification is a dynamic subject that studies the structure of the soil classification system, the definition of the classes used to classify soil, the criteria that determine soil classification, and its application in the field. Soil classification describes the mechanical characteristics of the soil, and also determines the quality of the soil for planning purposes and in carrying out construction. The classification system used in Soil Mechanics is intended to provide information regarding the technical properties of the materials in the same way as geological statements are intended to provide information regarding the geological origin of the materials.

SOIL COMPACTION

To determine the relationship between water content and volume weight, and to evaluate the soil so that it meets density requirements, a compaction test is generally carried out. The level of soil density is measured from the value of its dry volume weight (γd). For various types in general, there is a certain optimum water content value that reaches the maximum dry volume weight. The dry volume weight does not change with an increase in water content. The purposes of compaction include:

1. Increase the shear strength of the soil.
2. Reducing the easy nature of benefits.
3. Reducing permeability, and
4. Reducing volume changes as a result of changes in water content.

The relationship between dry volume weight (γd) with wet volume weight (γ) and water content (w) is expressed in the following equation:

$$\gamma d = \frac{\gamma}{1 + w}$$

Where:

γ = Wet volume weight

γd = Dry volume weight

w = Water content

The compacting tool used is a cylindrical mold which has a volume of 0.944 liters. The soil in the mold is compacted by pounding a load weighing 2.5 kg with a fall height of 30.5 cm. The soil was compacted in three layers, with each layer pounded 25 times. In the modified proctor test, the mold used was still the same, only the weight of the pounder was changed to 4.54 kg with a drop height of the pounder of 45.72 cm. In this test, the soil inside was pounded in 5 layers.

CBR *(California bearing radito)*

The CBR value is a comparison between the strength of a soil sample with a certain density and a certain water content to the strength of densely graded crushed stone as a material standard with a CBR value = 100. To find the CBR value, use the following formula:

$$CBR = \frac{test\ unit\ load\ (psi)}{standar\ unit\ load\ (psi)}\ x\ 100\%$$

The load is obtained from the reading of the penetration dial which is then correlated with the Calibration Prooving Ring graph. Test unit load (psi) = stress (σ).

$$\sigma = \frac{P}{A} = \frac{M\ (LRC)}{A}$$

RESEARCH METHODOLOGY

GENERAL

The method used in this research is to carry out testing in the CV. GLOBAL ENGINEERING laboratory on sukarela street (KM7), Sukarami subdistrict, Palembang City. The work began with a literature study regarding soil stability, then continued with taking soil samples for this research. The soil samples tested came from Rambutan subdistrict, H.M. Noerdin Pandji street, Banyuasin district, South Sumatra. After taking soil samples, physical soil testing is carried out, namely water content, soil grain size analysis (sieve analysis and hydrometer), Atterberg testing (plastic limit testing and liquid limit testing), and soil specific gravity. Testing of soil mechanical properties was also carried out, namely soil compaction (Standard Proctor) and CBR (California Bearing Ratio) testing. This test was carried out on soil mixed with bamboo leaf ash and cement with variations in the bamboo leaf ash mixture of 0%, 2%, 3%, 4%, 5% and 6% while the cement was 20%.

SOIL SAMPLE

Soil samples came from Rambutan sub-district, Jl. H.M. Noerdin Pandji, Banyuasin district, South Sumatra. This soil was taken at a depth of ± 1 m with the aim of ensuring that the soil samples taken did not contain rubbish or grass, then the soil samples were first dried under the hot sun. Next, the soil was taken to the CV . GLOBAL ENGINEERING laboratory on the sukarela road (KM7), Sukarami District, Palembang City.

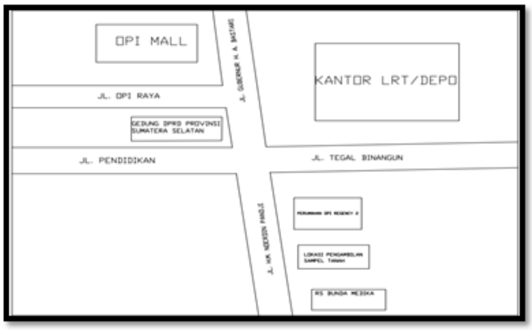


Image 1. location of soil sampling

Bamboo Leaf Ash Sample

These bamboo leaves were taken from the garden in Muara Enim hamlet, Muara Enim city. The bamboo leaves used are bamboo leaves that have fallen on the ground, then the bamboo leaves are dried in the hot sun until the bamboo leaves dry. Next, the bamboo leaves are burned until they turn blackish. After the bamboo has turned black, the bamboo leaves are put into a can and burned again using a torch until they become ash (turn grayish).

Image 2. Bamboo leaf ash

Cement

The cement used is of the PCC (Portland Composite Cement) type, this cement can be widely used for general construction, is easy to obtain, and is mostly used by the general public. The cement used in this test is of the Baturaja cement brand.

Image 3. cement

Material Testing

This research uses clay soil. The condition of clay soil at each location is of course different, so it is necessary to test the physical properties of clay soil. The clay used is clay in a disturbed condition, where this soil is obtained by digging the soil and then putting it in a sack, when it arrives at the laboratory the chunks of soil are removed and dried. After the soil sample was dried, the soil was pounded and sieved using sieve No. 4. After preparing the soil to be tested, the soil testing is then carried out.

Water Content Testing

Soil water content is a comparison between the weight of water (Ww) in a unit of soil and the weight of soil grains (Ws) and is expressed in per (%). In this test, the soil water content value was 43.63%.

Sieve Analysis Testing

The size distribution of coarse-grained soil can be determined by sieving. The method is to filter the test object (soil) through a set of standard filter units. This test was carried out to determine grain gradation (grain size distribution), by shaking 200 grams of dry soil for 15 minutes in a set of sieves and then letting it sit for 5 minutes. The weight of the soil remaining on each sieve is then weighed, the percentage of the soil weight is then calculated. In this test, the following results were obtained:Lolos saringan 2” = 100%

a. Passed the 1” filter = 100%
b. Passed the ¾” filter = 100%
c. Passed the 3/8” filter = 100%
d. Passed the 4 filter = 100%
e. Passed the 10 filter = 95,49%
f. Passed the 20 filter = 93,49%
g. Passed the 40 filter = 82,76%
h. Passed the 60 filter = 4,51%
i. Passed the 100 filter = 12,73%
j. Passed the 200 filter = 12,73%
k. PAN = 82,76%

From the results of the soil that passes the filter, results are obtained to determine the AASHTO classification of the soil and the USCS classification of the soil. From this test, the clay soil tested was included in group A-7-5 in the AASHTO classification and included in group MH (inorganic clay).

Plastic Limit Testing

The plastic limit of a soil is the boundary between the soil and its plastic state. In this case, the plastic properties are determined based on conditions where the soil is ground with the palm of the hand on the surface of the glass until it reaches 3 mm and there are cracks on the surface of the soil. In the tests carried out, the PL (Plastic Limit) value was 31.99%.

Liquid Limit Testing

The liquid limit is defined as the soil water content at the boundary between the liquid state and the plastic state. This test uses a Cassagrande tool. In this test, the LL (Liquid Limit) value was obtained at 52.98%.

Specific Gravity Testing

Soil specific gravity is the ratio between the weight of soil grains and the weight of distilled water with the same contents at a certain temperature. The specific gravity of the soil is needed to plan building construction with its strength being influenced by the specific gravity of the soil. The results of the liquid limit test obtained an average specific gravity value of 2,708. From these results it was stated that the soil type was an inorganic clay type.

Hydrometer Testing

Hydrometer analysis is one way of analyzing soil grain size distribution based on soil sedimentation in water. This method includes the determination of the grain size distribution of soil that passes sieve no. 200. The purpose of hydrometer analysis is to determine the grain size distribution of fine-grained soil. The results of the hydrometer test are as follows:

Table 1. Hydrometer test results

Elapse Time	% Finer by Tot Weight
0.5	77.83
1	74.56
2	70.46
5	63.09
15	58.17
30	53.25
60	49.98
240	44.24
1440	36.87

From this test, it was found that the number of soil grains measuring < 0.075 mm was 82.757 gr and the number of soil grains measuring > 0.075 mm was 12.732 gr. And from this test, the type of soil obtained is clay because there are more soil grains < 0.075 than the number of soil grains > 0.075.

Testing Silica Content in Bamboo Leaves

The aim of testing the content in bamboo leaf ash is to find out how much silica content is in the leaf ash. This test was carried out at the Palembang Industrial Standardization and Services Center Testing Laboratory. In this test, the results obtained were silica (SiO_2) content of 64.24%.

Making Test Objects

In this research, the test object was a mixed soil made based on variations in the addition of bamboo leaf ash and cement as additives. The number of test objects used was determined based on the percentage ratio between bamboo leaf ash and the weight of clay and cement. With a sample maintenance period of 4 days, the aim is to ensure that the water content is even and there is a reaction of cement and leaf ash on the clay soil.

Clay soil samples that will be used as test objects will first be dried in the hot sun. Testing for the physical properties of the soil is in the form of soil water content testing, specific gravity, Atterbeg Limit testing (plastic limit and liquid limit), sieve analysis and hydrometer testing. Soil mechanical properties testing includes Soil Compaction and CBR (California bearing radiation) testing. The planned percentages of ash, bamboo and cement additions can be seen in the

Table 2. The amount of bamboo leaf ash and cement added

Variasi abu daun bambu	Variasi semen	Jumlah sampel tanah
0%	20%	100 %
2%	20%	100 %
3%	20%	100 %
4%	20%	100 %
5%	20%	100 %
6%	20%	100 %

Table 3. Number of test object samples

Pengujian	ADB 0% Semen 20%	ADB 2% Semen 20%	ADB 3% Semen 20%	ADB 4% Semen 20%	ADB 5% Semen 20%	ADB 6% Semen 20%	Jumlal sampe
Pemadatan Tanah	5	5	5	5	5	5	30
California Bearing Radito	3	3	3	3	3	3	18
Jumlah							48

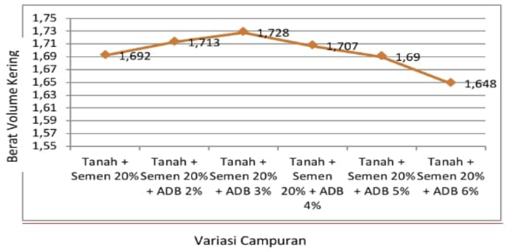
RESULTS AND DISCUSSION

Results and Discussion of Soil Compaction (Standard Proctor) Based on the results of soil compaction testing (Standard Proctor). It shows that at the beginning the optimum water content value decreased and conversely the maximum dry volume increased, along with increasing bamboo leaf ash content in the soil, the optimum water content increased and the maximum dry weight decreased. In table 4 below shows the data from the soil compaction test (standard proctor) which can be seen in the table below, so a graph can be made of the maximum dry volume and optimum water content of each mixture variation which can be seen in graphs 4 and 5.

Table 4. Soil compaction test results data (standard proctor)

Variasi Campuran	Berat Volume Kering Maksimum (gr/cm³)	Kadar Air Optimum (%)
Tanah + Semen 20%	1.692	17.03
Tanah + Semen 20% + ADB 2%	1.713	16.45
Tanah + Semen 20% + ADB 3%	1.728	16.02
Tanah + Semen20% + ADB 4%	1.707	16.65
Tanah + Semen 20% + ADB 5%	1.690	17.80
Tanah + Semen 20% + ADB 6%	1.648	18.77

From the results of soil compaction tests (Standard Proctor) carried out in this research, a graph of the maximum dry volume weight was created with different mixture variations, which can be seen in the graph below.



Images 4. soil dry volume weight

From the results of soil compaction tests (Standard Proctor) carried out in this research, a graph of optimum water content was created with different mixture variations, which can be seen in the graph below.

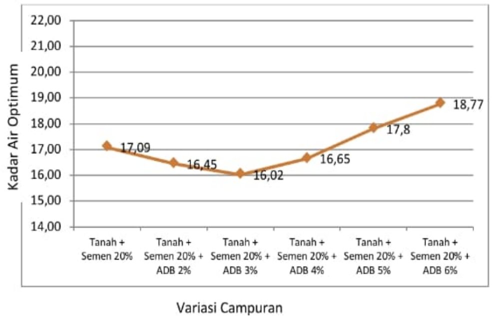


Image 5. Optimum water content value

Quoted from the book Basics of Soil Mechanics, it states that in the soil compaction process the dry volume weight will increase as the water content increases, but when the water content exceeds a certain water content, the increase in water content will actually reduce the dry volume weight of the soil. Therefore, the lower the water content value, the higher the dry volume weight value. The initial increase in soil density was due to improved soil gradation, so that the pore cavities became smaller because they were filled with fine grains in the soil. The shrinking of pore cavities causes some of the ground water that previously filled the pore cavities to move out of position, so that the optimum water content of the soil decreases. As the percentage of bamboo leaf ash increases, the soil gradation worsens so that the cavities enlarge. If these cavities are filled with water, the optimum water content of the soil increases and the soil density decreases. The best soil density value is shown in the variation of 3% bamboo leaf ash + 20% cement. In this condition, soil density increases by 0.036% of the original soil density, while the optimum water content decreases by 1.07% of the original soil's optimum water content.

Results and Discussion of Unsoaked CBR (California Bearing Ratio)

The results of the Unsoaked CBR (California Bearing Ratio) research with variations in the mixture of 2%, 3%, 4%, 5%, 6% bamboo leaf ash and 20% cement. The table below shows the Unsoaked CBR (California Bearing Ratio) test results data which can be seen in the table below.

Table 5. Percentage value of Unsoaked CBR (California Bearing Ratio) results

Variasi Campuran	Persentase hasil CBR *(California Bearing Ratio) Unsoaked* (%) 4 hari Pemeraman
Tanah + Semen 20%	6.11
Tanah + Semen 20% + ADB 2%	8.33
Tanah + Semen 20% + ADB 3%	10.25
Tanah + Semen 20% + ADB 4%	9.82
Tanah + Semen 20% + ADB 5%	9.43
Tanah + Semen 20% + ADB 6%	9.00

From the CBR Unsoaked (California Bearing Ratio) test results data obtained in this research, a graph was made of the percentage value of CBR Unsoaked (California Bearing Ratio) with different mixture variations, which can be seen in the graph below.

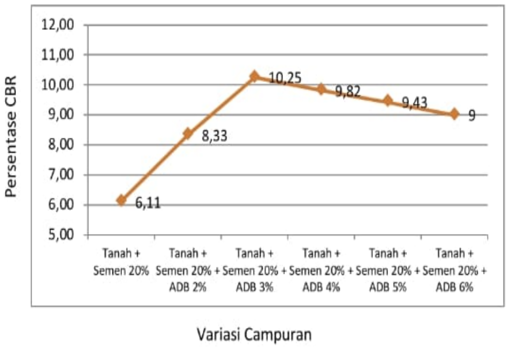


Image 6. CBR (California Bearing Ratio) Unsoaked value

Based on the basic soil classification table, and based on CBR, it shows that the greater the CBR value, the better and harder the soil. In the CBR testing that has been carried out, the CBR value increases from the minimum value. In variations of 3% bamboo leaf ash and 20% cement, the soil percentage value increased by 4.11% from the original soil. The value obtained from variations of 3% bamboo leaf ash and 20% cement was 10.25%. From these results, the optimum CBR value is in the variation of a mixture of 3% bamboo leaf ash and 20% cement.

CONCLUSION

From the two tests that have been carried out, namely soil compaction (Standard Proctor) and CBR (California Bearing Ratio) Unsoaked, the following conclusions can be drawn:

The optimum values obtained for soil compaction (Standard Proctor) and Unsoaked CBR (California Bearing Ratio) were in variations of adding soil + 20% cement + 3% Bamboo Leaf Ash. In the soil compaction test (Standard Proctor) the dry volume weight value was 1,728 gr/cm3 and the optimum water content value was 16.02% and in the Unsoaked CBR (California Bearing Ratio) the optimum CBR percentage value was 10.25%

SUGGESTION

Based on the tests that have been carried out, the following suggestions can be drawn:

Further research needs to be carried out by changing cement as a variable addition and bamboo leaf ash as a constant addition so that the results of this research can be compared with that research. It is necessary to be thorough and careful in carrying out laboratory tests, especially when using equipment that must comply with procedures to obtain more valid and maximum results.

REFERENCES

1. Darwis. 2018. *Dasar-dasar Mekanika Tanah*. Yogyakarta: Pena Indis.
2. Mina, e, Kusuma, R. I., Susilo, R. E. (2019). *Pemanfaatan Abu Sisa Pembakaran Daun Bambu Untuk Stabilitas Tanah Dan Pengaruhnya Terhadap Nilai Kuat Tekan Bebas (Studi Kasus : Jl. Munjul-Malingping, Desa Pasir Tenjo, Kec. Sindang Resmi, Kab. Pandeglang)*. Teknika : Jurnal Sains dan Teknologi Vol 15 No 2 (2019) 85-91.
3. Hardiyatmo, H. C. 2002. *Mekanika Tanah 1*. Yogyakarta : Gadjah Mada Univrsity Press.
4. Wijaya, W. 2021. *Pengaruh Stabilisasi Abu Daun Bambu dan Semen Terhadap Kembang Susut (Swelling) Tanah Lempung Ekspansif.* Jurnal Teknik Sipil Volume 16, No.2 April 2021 : 105-112.
5. Zhafirah, A., Muslimah, A., H. 2021. *Pengaruh Penambahan Abu Daun Bambu dan Semen Terhadap Stabilitas Tanah*. Jurnal Konstruksi Vol. 19, No. 1 2021 : Hal 286-294.
6. Andriani, Yuliet, A., Fernandez, F. L. 2012. *Pengaruh Penggunaan Semen Sebagai Bahan Stabilisasi Pada Tanah Lempung Daerah Lambung Bukit Terhadap Nilai CBR Tanah*. Jurnal Rekayasa Sipil Vol. 8, No. 1, Februari 2012.
7. Kabdiyono, E. A. 2019. *Pengaruh Penambahan Abu Daun Bambu (BLA) dan Kapur Terhadap Nilai CBR Pada Stabilisasii Tanah Lempung Berlanau Untuk*

Konstruksi Jalan. Jurnal Ilmiah Desain dan Konstruksi Vol. 18, No.1 Juni 2019.

8. Lesmana, I. L., Muhardi, Nugroho, S. A. 2016. *Stabilitas Tanah Plastisitas Tinggi Dengan Semen*. Jom FTEKNIK Vol.3, No.2 Oktober 2016.
9. Joni, R., S. 2004. *Evaluasi Nilai CBR Pada Tanah Dasar (Subgrade) Jalur Jalan Bandung-Cianjur Dengan Menggunakan Alat Dynamic Cone Penetrometer*. Buletin Geologi Tata Lingkungan, Vol. 14, No. 1, Juni 2004, 1-7.
10. BADAN STANDARDISASI NASIONAL. 2008. *SNI 1742:2008 Cara Uji Kepadatan Ringan Untuk Tanah*. BSN. Jakarta.
11. BADAN STANDARDISASI NASIONAL. 2008. *SNI 3423:2008 Cara Uji Analisis Ukuran Butir Tanah*. BSN. Jakarta.
12. BADAN STANDARDISASI NASIONAL. 2012. *SNI 1744:2012 Metode Uji CBR Laboratorium*. BSN. Jakarta.
13. BADAN STANDARDISASI NASIONAL. 2008. *SNI 1966:2008 Cara Uji Penentuan Batas Plastis dan Indeks Plastisitas Tanah*. BSN. Jakarta.