Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 12, pp.42851-42855, December, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

TAYSAN SOIL MIX WITH CALACA BOTTOM ASH AS AN ALTERNATIVE ROAD BASE MATERIAL

***ExpeditoV. Acorda**

Civil Engineering Department, College of Engineering, Architecture and Fine Arts, Batangas State University

ARTICLE INFO

Article History:
Received 03rd September, 2016
Received in revised form
24th October, 2016
Accepted 16th November, 2016
Published online 30th December, 2016

Key words:

Atterberg Limit,
California Bearing Ratio,
Plastic Limit,
Liquid Limit,
Road base.

ABSTRACT

The focused of the study is to determine the viability of Taysan Soil mixed with Calacabottom ash (CBA) as an alternative road base material. The study also aimed to determine the varying proportions of each sample and select the best proportion that would serve as the basis for the road base material. Findings showed that the soil sample has a moisture content of 7.32%. While the soil sample obtained of a plastic limit of 16.54%, a liquid limit of 22.58% and aplasticity index of 6.04%. The liquid limit did not exceed 25% and the plasticity index attained the 6% requirement of the DPWH Standard Specification. Based on the result of particle size the soil sample is composed mostly of gravel according to the USCS and AASHTO having a percentage of 76.387% and 87.723% respectively. However the soil sample attained a CBR value of 89% at 100% dry density and 73% at 95% dry density. The California Bearing Ratio (CBR) value of the Taysan soil is greater than 80% as required by the DPWH standard specification. Furthermore, moisture content of 15.42% and CBA is a non – plastic material. In terms of particle size based on CBA sample according to AASHTO is consists of 52.23% of gravel, 41.56% of sand and 6.21% of clay while according to the USCS, it consists of 32.30% of gravel, 61.49% of sand and 6.21% of clay. The CBR values of the Taysan soil with CBA increases as the percentage of CBA increases.

Citation: ExpeditoV. Acorda, 2016. "Taysan soil mix with calaca bottom ash as an alternative road base material", *International Journal of Current Research,* 8, (12), 42851-42855.

INTRODUCTION

Roads are an integral part of the transport system. A country's road network should be efficient in order to maximize country's economic and social benefits. In transportation, land travels are mostly used by the society. Some importance is improvement of agricultural production through farm to market roads. Another is the accessibility of health services to the people especially in rural areas (Ghafoori, 2000). Engineers emphasized the major role in constructing roads and highways which should be in accordance with the standard requirements of the department of public works and highways. Normally, road construction layers are composed of sub-grade, sub-base, base course and pavement (Konrad, 2006). Road base course shall consist of foundation for surface course composed of soil aggregate, lime and water in proper proportions, road-mixed and constructed on a prepared sub-grade or sub-base. A base course is the layer immediately under the wearing surface. Because the base course lies under the pavement surface, it is subjected to severe loading. It follows that the materials in a base course must be of extremely high quality and construction must be carefully done. This study focused on using the Taysansoil material added with Calaca Bottom Ash as an improved road base material. The coal-fired power plant of the D.M.CONSUNJI, Incorporated (DMCI), formerly known as National Power Corporation (NAPOCOR) in San Rafael, Calaca, Batangascombusts coal that generates enormous quantity of solid byproducts like bottom ash. It emits an estimated 62.62 tons of coal combustions products per hour on a 24-hour daily basis. Most modern pulverizing coal boilers, like the one installed at Calaca, Batangas, have dry bottom furnaces; that is, the ash is intended to be removed as a dry solid before complete melting occurs. This byproduct is referred to as bottom ash (Antonio *et al*., 2007). The chemical composition of bottom ash provides unique pozzolanic properties that, as with cementitious materials, can result in a favorable time-independent increase in strength.

According to 2006 statistics on bottom ash usage, just over 45 percent of all bottom ash produced is used, mainly in transportation applications such as structural fill, road base material, and as snow and ice control products (Kalyoncu and Kelly, 2002). On the other hand, the quarry site located at Brgy. Sto. Nino, TaysanBatangas produces sub-base course and base course materials. The base course from the said quarrying area had passed the tests and considered as standard base course according to the DPWH Standard Specifications for Public Works and Highway. In this light, the researchers

Corresponding author: ExpeditoV. Acorda,
Civil Engineering Department, College of Engineering, Architecture and Fine Arts, Batangas State University

attempted to determine the viability of mixing Taysan Soil and Calaca Bottom Ash as an alternative road base material.

Objectives of the Study

This study aimed to evaluate the viability of Taysan Soil mixed with Calaca Bottom Ash as an alternative road base material. Furthermore, it sought to answer the following questions:

1. What are the engineering properties of Taysan Soil in terms of:
1.1. Moisture Content Determination
1.2. Sieve Analysis
1.3. Plastic Limit and Liquid Limit Test
1.4. California Bearing Ratio
2. What are the engineering properties of Calaca Bottom Ash in terms of:
2.1. Moisture Content Determination
2.2. Sieve Analysis
2.3. Plastic Limit and Liquid Limit Test
3. How does the California Bearing Ratio of Taysan Soil mixed with Calaca Bottom Ash in three different proportions such as 95% natural soil – 5% bottom ash, 90% natural soil – 10% bottom ash and 85% natural soil – 15% bottom ash as compared with the 100% natural soil – 0%?

MATERIALS AND METHODS

Pre-laboratory tests were conducted to determine the applicability of the samples. It included the analysis of the grain size, determination of Atterberg limits and California Bearing Ratio (American Society for Testing and Materials, Annual Book of ASTM Standards, 1997). The materials used in this study are the Taysan Soil and Calaca Bottom Ash. The soil was gathered from the quarry at Sto. Ninio, TaysanBatangas andthe bottom ash were from the coal-fired power plant of the DMCI formerly NAPOCOR in San Rafael, Calaca, Batangas. Prior to the determination of engineering properties of Taysan Soil and Calaca Bottom Ash, the following test parameters were determined such as Moisture determination, particle size, Atterberg limit in terms Plastic limit and Liquid limit, and California Bearing Ratio Test.

Moisture Content

Moisture content is important because it gives a first indication of the condition or consistensy of the material. It is defined in geotechnical engineering as the ratio of the weight of water to the weight of solid in a given mass of soil.

$$\omega = \frac{W_w}{W_s} x100$$

where: W_w = weight of water, W_s = dry weight of the soil solid

The moisture content is determined by taking a sample of soil weighing it, drying it in an oven at specific temperature (usually 105 to 110 degree Celsius) and then weghing it again after drying.

Particle-Size Analysis

Sandard test method for sieve analysis provided in ASTMD 422-63 was used. The test method covered the quantitative determination of the distribution of the particle done by sieving. Standard test method for sieve analysis and hydrometer analysis of soils provided in ASTMD 422 – 63 will be used. This test method covers the quantitative determination of the distribution of particle sizes larger than 75 µm (retained on the No. 200 sieve) is determined by sieving, while the distribution of particle sizes smaller than 75 µm is determined by sedimentation process, using a hydrometer to secure the necessary data. The knowledge of the sizes of solid particles comprising a certain soil type and their relative proportion in the soil mass is often useful. Particle-size distribution is used in soil classification, soil filter design, and used to predict in a general way how a soil may behave with respect to shear strength, settlement, and permeability.

Soil Classification

Standard classification of soils for engineering purposes provided in ASTM D 248 – 92 will be used. This standard describes a system for classifying mineral and organo-mineral soils for engineering purposes based on laboratory determination of particle-size characteristics, liquid limit, and plasticity index and shall be used when precise classification is required. The group symbol portion of this system is based on laboratory tests performed on the portion of a soil sample passing the 3-in. (75-mm) sieve. As a classification system, this standard is limited to naturally occurring soils. This standard is the ASTM version of the Unified Soil Classification System (USCS).

Determination of Atterberg Limits

The atterberg limits are useful in defining the limits of various stages of consistency in fine-grained soils. They provide a convenient index of the plastic behavior of soils.

Liquid Limit

A 150-200g soil sample is prepared for testing by mixing soil at its natural water content with distilled water to reach a consistency requiring 15 to 20 blows of the liquid-limit device to close a 1/2 –in-long groove. A portion of the prepared soil is spread and smoothed into the brass liquid-limit cup to a depth of 10mm and a standard groove is cut through the soil using a specific grooving tool. The cup is then caused to drop at a rate of 1.9 to 2.1 drops per second until the soil flows together for a distance of ½in along the groove. The remaining soil is remixed to decreasethe water content then the procedure is repeated at least three times.

Plastic Limit

The plastic limit is determined by selecting a 20g sample of material prepared for the liquid limit test. The water content should be reduced by spreading and mixing on a dry glass plate until the soil has a consistency that will allow rolling without sticking to the hands. The soil mass is placed on the glass plate and rolled by hand to form a thread.

The thread is the re-formed into an elongated ball and rerolled to 1/8in diameter. This process is repeated until the thread crumbles and can no longer be rolled into a thread. At this point, plastic limit has been reached.

California Bearing Ratio Test

This test was developed by California Highway Department and was first used as the basis for an empirical flexible pavement design procedure in 1929. The cbr test is both laboratory and a field test. Laboratory-compacted samples are tested to determine the design CBR for a particular material. The CBR test measures a soil's resistance to penetration and compares those results with a standard set of values to determine the CBR value for that particular soil.To calculate the CBR as a percentage, the load at each penetration value for the test specimen is divided by the corresponding standard load and multiplied by 100.

Flow of the Experimental Study

The classification of Taysan Soil and Calaca Bottom Ash were determined. Different laboratory experiments were conducted to determine the engineering properties such as moisture content, plastic limit and liquid limit, and the grading analysis of the soil sample and CBA. The soil sample and ash were air-dried. Then the soil sample was mixed with CBA into different proportions of 5%, 10% and 15% of the dry weight of the soil sample. The specimens were cured for 5 days. The cured specimens undergo laboratory test to determine its CBR values. The data gathered were averaged and compared.

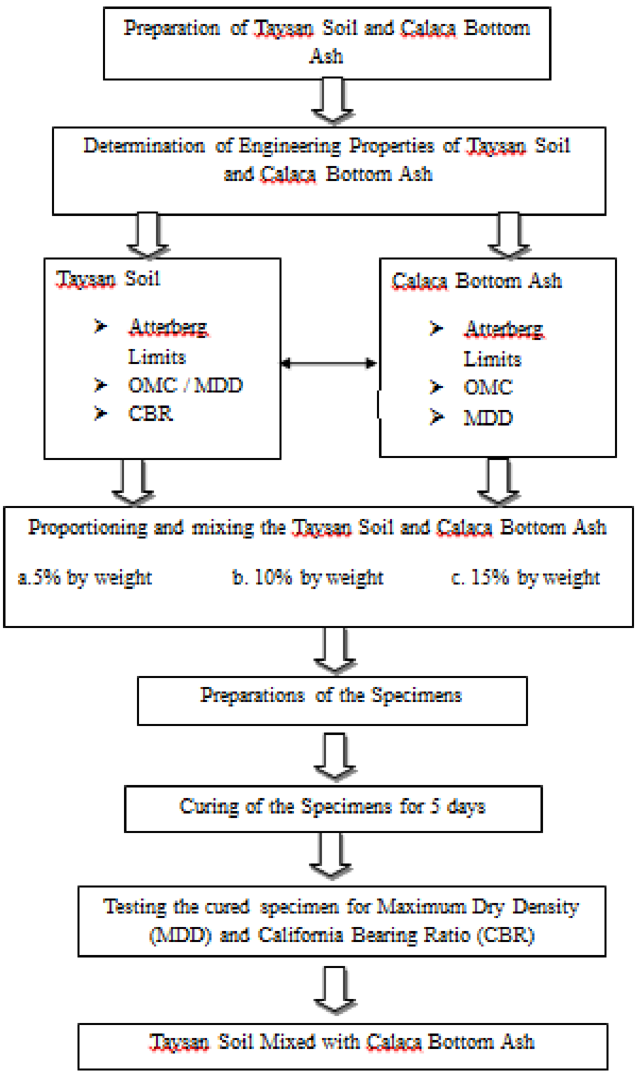

Figure 1. Taysan Soil and Calaca Bottom Ash Mix Process

RESULTS AND DISCUSSION

EngineeringProperties of Taysan Soil

Table 1. Engineering Properties of Taysan Soil

Specimen Property	Taysan Soil
Moisture Content	7.32%
Plastic Limit	16.54%
Liquid Limit	22.58%
Plasticity Index	6.04%

Table 1 shows that the Taysan soil has a moisture content of 7.32%, a plastic limit of 16.54%, a liquid limit of 22.58% and a plasticity index of 6.04%. According to the DPWH Standard Specification for Base course, the liquid limit must not be greater than 25% and should have a plasticity index not greater than 6%. It shows that the Taysan Soil meets the requirements of the standard base course.

Grading Analysis of Taysan Soil

Table 2. Grading Analysis of Taysan Soil

Sieve No.	Sieve Size (mm)	Mass Retained(g)	%Retained	%Passing
1'1/2	38.1	126.16	8.796	91.204
1	25.4	165.27	11.522	79.682
¾	19.1	206.76	14.415	65.267
½	12.7	191.45	13.347	51.92
3/8	9.52	121.38	8.463	43.457
# 4	4.75	284.62	19.844	23.613
#8	2.36	162.59	11.336	12.277
#40	0.42	113.09	7.885	4.392
#80	0.177	31.98	2.23	2.162
#200	0.074	17.12	1.193	0.969
Pan		13.9	0.97	0
Total		1434.32	100	0

The table shows the %retained and %passing of soil through sieving. It shows that 79.682% passed through a 25.4mm sieve size, 23.613% passed through a 4.75mm sieve, 4.392% passed through a 0.42mm sieve and 0.969% passed through a 0.074mm sieve.

California Bearing Ratio Results of Taysan Soil

Table 3. California Bearing Ratio Results of Taysan Soil

Trial	DD	MC	CBR	
			@100%	@95%
1	1.706	1.51	89%	73%
2	1.786	2.89		
3	1.922	5.23		
4	2.164	8.41		
5	1.93	11.43		
Maximum	2.164	8.41		

The Table 3 revealed that at a maximum dry density of 2.164% and optimum moisture content of 8.41%, the specimen obtained a CBR value of 89% and 73%. This shows that Taysan Soil passed the requirement of the standard base course having a CBR value of 80 and above for a National Highway.

Engineering Properties of Calaca Bottom Ash

The table indicated that Calaca Bottom Ash has a moisture content of 15.42% and based on the experiment, it is a non-plastic material.

Table 4. Engineering Properties of Calaca Bottom Ash

Specimen Property	Calaca Bottom Ash
Moisture Content	15.42%
Plastic Limit	NIL
Liquid Limit	NIL
Plasticity Index	NP

Grading Analysis of Calaca Bottom Ash

Table 5. Grading Analysis of Calaca Bottom Ash

Sieve No.	Sieve Size (mm)	Mass Retained (g)	%Retained	%Passing
1'1/2	38.1	-	-	100
1	25.4	9.5	0.69	99.31
¾	19.1	55.23	4.01	95.3
½	12.7	120.65	8.76	86.54
3/8	9.52	51.05	3.71	82.83
# 4	4.75	208.31	15.13	67.7
#8	2.36	274.35	19.93	47.77
#40	0.42	287.69	20.9	26.87
#80	0.177	223.74	16.25	10.62
#200	0.074	60.72	4.41	6.21
Pan		85.48	6.21	0
Total:		1376.72	100	0

This table shows the %retained and %passing of bottom ash through sieving. It shows that 99.31% passed through a 25.4mm sieve size, 67.7% passed through a 4.75mm sieve, 26.87% passed through a 0.42mm sieve and 6.21% passed through a 0.074mm sieve..

Comparison of the California Bearing Ratio Test Results

Table 6 presents the different proportions of the mixture that the researchers used in the study. It also includes the maximum dry density, optimum moisture content and CBR value at 100% dry density and 95% dry density.

Table 6. California Bearing Ratio Results of Taysan Soil – CBA

Proportions	Trial	DD	MC	CBR	
				@100%	@95%
100% TaysanSoil - 0% CBA	1	1.706	1.51	89%	73%
	2	1.786	2.89		
	3	1.922	5.23		
	4	2.164	8.41		
	5	1.93	11.43		
	Max	2.164	8.41		
95% Taysan Soil - 5% CBA	1	1.772	2.68	36.50%	25%
	2	1.873	4.83		
	3	1.995	7.02		
	4	1.9	10.18		
	Max	2.01	7.6		
90% Taysan Soil - 10% CBA	1	1.68	3.04	39.75%	30.75%
	2	1.771	5.47		
	3	1.868	7.25		
	4	1.802	10.29		
	Max	1.878	8.1		
85% Taysan Soil - 15% CBA	1	1.624	3.73	51.50%	41.50%
	2	1.736	5.48		
	3	1.849	7.22		
	4	1.767	10.55		
	Max	1.865	8		

CBA with their corresponding CBR values are presented in Table 6. It shows that the Taysan soil reached its maximum dry density of 2.164 at an optimum moisture content of 8.41%. It obtained a CBR value of 89% and 73% at 100% and 95% dry densities. It shows that the Taysan Soil with 15% of CBA got the highest value of CBR at 51.50% and 41.50%. The lowest value of CBR was obtained by the Taysan Soil with 5% CBA. According to the DPWH Standard Specification for Base course, the CBR value of a base course must not be less than 80%. The CBR values obtained by the mixtures were lower than the standard base course.

Figure 2 shows the CBR Test Results of Specimens with Varying Proportions @ 100% and 95% dry densities

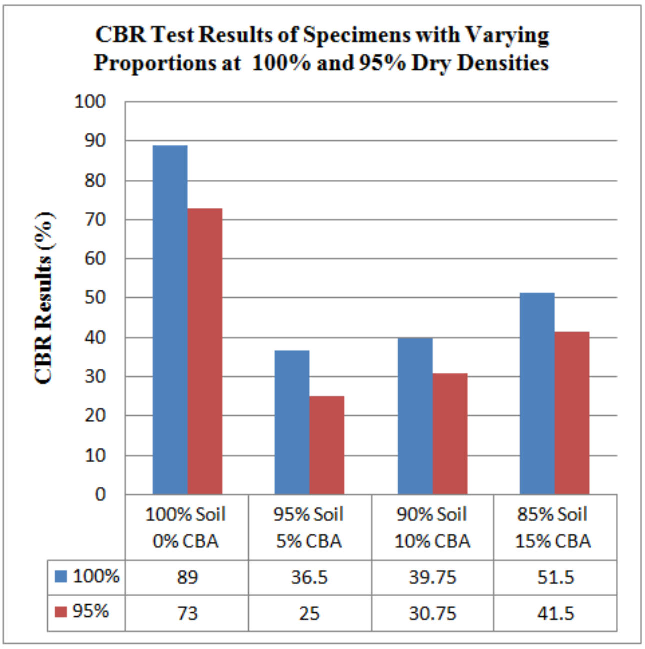

Figure 2. CBR Test

Figure 2 shows the CBR Test Results of specimens The soil specimen having 15% CBA obtained the highest value of CBR while the 5% CBA obtained the lowest CBR value. These results show that the Taysan Soil with 5%, 10% and 15% CBA meet the requirements of a standard base course but has a low quality.

Conclusion and Recommendation

Based from the prior results of experiments and investigations, the researchers arrived at the following conclusions.

1. The properties of Taysan Soil meet the standard specification for an aggregate base course. It is considered as a base course for National Highways having a CBR value of 80% and above.
2. The Calaca Bottom Ash is a non plastic material which can increase the moisture content of a plastic material.
3. Among the three mixtures, the Taysan Soil with 15% CBA got the highest values of CBR which are 51.50% and 41.50%. It is considered as a base course for Barangay roads having a CBR value of 40% – 50% at MDD.
4. The CBR value of Taysan Soil is higher than the mixture of Taysan Soil with 15% CBA.The soil has a high quality than the mixture but the mixture is cost-eficient than the soil. Therefore, the Taysan Soil with Calaca Bottom Ash does not improved as a standard base course.

5. The Calaca Bottom Ash can be used as an additive to the Taysan Soil as a road base material for Barangay Roads.

Appendix

Appendixes, if needed, appear before the references.

REFERENCES

American Society for Testing and Materials, Annual Book of ASTM Standards, Philadelphia, 1997.

Antonio, Oscar Victor M. Jr., Zarco and Mark Albert H., "Engineering Properties of CalacaBatangas Bottom Ash", University of the Philippines Diliman, 2007 *Philippine Engineering Journal*, PEJ 2007; Vol. 28, No. 1:37-56

Ghafoori, N., "Large-Scale Utilization of Illinois PCC Bottom Ash in Roadways and Parking Lots of a Youth, Sports, Safety Complex", DCC grant number 96-205103 (CRG 27), 2000.

Kalyoncu, R.S. and Kelly, T.D. 2002. Coal combustion products statistics. Retrieved July 2, 2003, from http:// minerals.usgs.gov/minerals/pubs/of01006/coalcombustionproducts.html

Konrad, J.-M. "The use of tangent stiffness to characterize the resilient response of unbound crushed aggregates", *Canadian Geotechnical Journal*, Nov 2006 Issue

****