Utilization of Waste Tire Rubber Chips and Waste Plastic Strips for Soil Stabilization

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ABSTRACT

Soil fiber composites came from waste plastic material such as plastic and tire rubber have been found effective in improving the CBR value. This experimental study was conducted to determine the significant difference of waste tire rubber chips and waste plastic strips as admixtures for soil stabilization.

Soil stabilization is the permanent physical and chemical alteration of soils to enhance their physical properties. The term soil stabilization means the improvement of the stability or bearing power of the soil by the use of controlled compaction, proportioning and or the addition of suitable admixture or stabilizer.

Today, due to the fast growth of populations and development activities, it led to discharge of huge wastes. Disposal of these different wastes produced from different industries and urban areas has become a great problem. These materials, most of which are non-biodegradable posed environmental threat by polluting the nearby locality.

This report presents the various tests conducted on fiber reinforced soil with varying fiber content and different aspect ratio. Their results are analyzed such that significant difference of these two admixture which are waste plastic strips and waste tire rubber chips are determined.

Plastic strips and tire rubber chips are obtained from waste material are mixed randomly with the soil. A series of CBR tests were carried out on randomly reinforced soil by varying percentage of plastic strips and tire rubber chips to find out the change of CBR value of the fiber reinforced soil with respect to unreinforced soil. Results of CBR tests demonstrated that waste plastic strips have a greater value in bearing capacity than waste tire rubber chips.

Key words: soil stabilization, plastic strips, rubber tire, waste plastics

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INTRODUCTION

For any land-based structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very vital role. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behavior. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work. From the beginning of construction work, the necessity of enhancing soil properties has come to the light. Ancient civilizations of the Chinese, Romans and Incas utilized various methods to improve soil strength etc., some of these methods were so effective that their buildings and roads still exist.

In India, the modern era of soil stabilization began in early 1970's, with a general shortage of petroleum and aggregates, it became necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site. Soil stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favor. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement. (Sen & Kashyap, 2012).

Here, in this project, soil stabilization had been done with the help of randomly distributed plastic strips and tire rubber chips obtained from waste materials. The improvement of bearing ratio had been stressed upon and comparative studies had been carried out using method of California Bearing Ratio Test and Proctor Compaction Test.

STATEMENT OF THE PROBLEM

This study primarily determined the comparison of Waste Tire Rubber Chips and Waste Plastics Strips as an admixture for soil stabilization.

OBJECTIVES OF THE STUDY

1. To determine the properties of soil samples in terms of:

    1.1. Specific Gravity

    1.2. Plastic Limit

    1.3. Liquid Limit

    1.4. Moisture Content

    1.5. Particle Size Distribution by Sieve Analysis

2. To determine the bearing capacity of the control sample using CBR at .64 mm, 1.27 mm, 1.91 mm, 2.54 mm, 3.81 mm, 5.08 mm, 6.35 mm, 7.62 mm and 8.69 mm penetration.

3. To determine the bearing capacity of the soil with admixtures using CBR at .64 mm, 1.27 mm, 1.91 mm, 2.54 mm, 3.81 mm, 5.08 mm, 6.35 mm, 7.62 mm and 8.69 mm penetration.

4. To determine the significant difference of tire rubber chips and plastic strips as an admixture of soil for stabilization.

MATERIALS AND METHODS

Research Design

Since the study is concerned with the investigation of the significant difference of waste plastics strips and waste tire rubber chips on soil stabilization, the experimental method of research was used in this study. The experimental method of research is a procedure involving the control or manipulation of conditions for the purpose of studying the relative effects of various treatments applied to the members of the sample.

Collection of Data

We gathered the information and related studies on soil stabilization using plastics strips and tire rubber chips from the internet, books, articles, and previous studies of Civil Engineering students stored in the Mini Library of College of Engineering, Eastern Samar State University – Borongan. Mainly, the major data of the study were sourced out by the study of Arpan Sen (108CE019) and Rishabh Kashyap (108CE018).

Experimental Design

1. Gathering and Preparation of Materials

1.1 Gathering of Materials

1.1.1, Soil

Soil samples were gathered in places within the stated scope of this study. It was cleaned to be free from any organic materials.

1.1.2 Admixtures

Waste plastic bottles and tire rubber were gathered from the respective residential houses of researchers, neighbors and vulcanizing shops in Borongan City.

1.2. Material Preparations

All materials were stored at the laboratory room of the College Of Engineering, ESSU– Borongan City. Soil samples were cleaned and dried first before employing laboratory test. Plastic bottles and tire rubber were cut into the desired dimensions of this study.

2. Design Mixture of Specimen

2.1. Design of Specimens

In conducting this study, five types of specimens were used. Each soil sample was identified through their sources or from where samples were gathered. Specimen characterization is shown in Table 1.

Table 1. Characterization of Specimen

Sample/ Specimen	Description	Specimen ID	Sample/ Specimen	Description	Specimen ID
soil from Guiuan	Control Sample	GCS	soil from Borongan	Control Sample	BCS
	With Tire Rubber	GT1, GT2		with Tire Rubber	BT1, BT2
	With Plastic Strips	GP1, GP2		with Plastic Strips	BP1, BP2

This table shows/tells what specimen ID's to be used in classification of soil samples. Specimen ID's will be written on piece of paper and attached to the respective samples.

2.2. Mixture of Specimen

The design mixture used in this study was in accordance of volumetric method. The amounts of soil and admixtures are shown in Table 2 and 3.

Table 2. Specified volume of admixtures and soil from Guiuan, Eastern Samar

Specimen ID	% Volume of Soil	% Tire Rubber Chips	% Plastic Strips
GCS	100	0	0
GT1	90	10	0
GT2	80	20	0
GP1	90	0	10

GP2	80	0	20

Legend:
GCS – Soil from Guiuan, Control Sample
GT1 – Soil from Guiuan,10% Tire Rubber Chips
GT2 – Soil from Guiuan,20% Tire Rubber chips
GP1 – Soil from Guiuan,10% Plastic Strips
GP2 – Soil from Guiuan,20% Plastic Strips

Table 3. Specified volume of admixtures and soil from Borongan City, Eastern Samar

Specimen ID	% Volume of Soil	% Tire Rubber Chips	% Plastic Strips
BCS	100	0	0
BT1	90	10	0
BT2	80	20	0
BP1	95	0	10
BP2	90	0	20

Legend:
BCS –Soil from Borongan, Control sample
BT1–Soil from Borongan, 10% Tire Rubber Chips
BT2 – Soil from Borongan, 20% Tire Rubber Chips
BP1 – Soil from Borongan, 10% Plastic Strips
BP2 – Soil from Borongan, 20% Plastic Strips

Tables 2 and 3 shows the percentage volume of soil and admixture and which will be the basis of testing the specimens.

Design Mix Proportion Computation

Hence the researchers cited that the quantity of admixtures and soil samples will be based on volumetric method, the following computations were came up for which it helped the researchers in getting easily the required volume of admixtures.

$$\boldsymbol{V_S} = volume\ of\ soil\ samples$$

$$\boldsymbol{d} = diameter\ of\ cylindrical\ mould = 15\ cm\ \boldsymbol{h} = height\ of\ cylindrical\ mould = 17.5\ cm$$

$$\boldsymbol{V_S} = \frac{\pi d^2}{4} h = \frac{\pi(15\ cm)^2}{4}(17.5\ cm) = 3092.51\ cm^3$$

$\boldsymbol{V_S}$ is volume of soil without admixtures or denoted as control sample. Multiplying the $\boldsymbol{V_S}$ by the percentage of admixture to be added will have the required volume.

$$\boldsymbol{V_{S1}} = V_S \text{ x } 10\% = 3092.51 \text{ cm}^2 \text{ x } 0.1 = 309.25 \text{ cm}^3$$

$$\boldsymbol{V_{S2}} = V_S \text{ x } 20\% = 3092.51 \text{ cm}^2 \text{ x } 0.2 = 618.50 \text{ cm}^3$$

$$\boldsymbol{V_{S1}} = 309.25\ cm^3 = \frac{\pi(15\ cm)^2}{4} h_1, \qquad \boldsymbol{h_1} = \frac{4(309.25\ cm^3)}{\pi(15\ cm)^2} = 1.75\ cm$$

$$\boldsymbol{V_{S2}} = 618.50\ cm^3 = \frac{\pi(15\ cm)^2}{4} h_2, \qquad \boldsymbol{h_2} = \frac{4(618.50\ cm^3)}{\pi(15\ cm)^2} = 3.5\ cm$$

$\boldsymbol{V_{S1}}$ is the volume of admixture as to 10% and $\boldsymbol{V_{S2}}$ is the volume of admixture as to 20%. The h_1 represents needed height of 10% admixtures and h_2 for 20% admixtures.

Experimental Procedure

Specific Gravity

Both soil samples from different source with the same volume are weighed. To compute the specific gravity, the recorded weight of each soil samples were divided to their volume and the quotient is multiplied by the unit weight of water.

Moisture Content of Soil Samples

300 grams soil samples (Ww) were oven dried at 105^0C. After drying and letting it cool, it was weighed again. The moisture content was calculated by the difference of wet soil (W_w) and dried soil sample (W_D) divided by the dried sample (W_D) and multiply the quotient by 100%.

Particle Size Distribution (Soil from Guiuan and Borongan)

A weighed sample of dry soil is separated through a series of progressively smaller openings for determination of particle size distribution. A 1 minute sieve operation was done by means of lateral and vertical motion of the sieves accompanied by varying action to keep the sample moving continuously on the surface of the sieve. The sample was weighed and

recorded as the quantity retained on the sieve. Percent passing was computed for each sieve and compared the percent passing.

Determination of Load Bearing Capacity of Soil Samples

A series of California Bearing Ratio (CBR) tests were carried out on randomly reinforced soil by varying percentage of plastic strips and tire rubber chips.

As per ISI, the CBR test was performed on remolded soil by static compaction. Following the design and mixture of the specimen, these compacted soil samples are prepared for CBR test.

Required amount of plastic strips and tire rubber chips as well as soil from different sources was first computed using volumetric method and then plastic strips and tire rubber chips are randomly mixed with dry soil at obtained moisture content. The soil was compacted in three equal layers by applying 25 evenly distributed blows with 4.89Kg hammer at free fall height. Due care was taken to ensure a homogeneous mix. A surcharge weight of 2.5 Kg was placed over the specimen, clamped over the base plate and the whole mould with the weight is placed under the testing machine.

The penetration plunger is seated at the center of the specimen and is brought in contact with the top surface of the soil sample by applying a seating load of 4Kg. The dial gauge for measuring the penetration values of the plunger is fitted in position. The dial gauge of the proving ring (for load reading) and the penetration dial gauge are set to zero. The load is applied through the penetration reading of.64 mm, 1.27 mm, 1.91 mm, 2.54 mm, 3.81 mm, 5.08 mm, 6.35 mm, 7.62 mm, and 8.69 mm.

RESULTS AND DISCUSSION

This chapter presents the results, analysis and interpretation of data based on the observations and tests conducted. These include the laboratory tests of soil samples such as moisture content, specific gravity, sieve analysis, plastic limit and liquid limit of soil samples. Also include the test of California Bearing Ratio for every soil samples conducted at DPWH-Borongan.

Results and Discussion of Experiment

Table 4. Tabular Representation of Specific Gravity of Soil Samples

source of Soil sample	weight of soil (W_S)	volume of soil (V_S)	unit weight of water (Y_W)	Specific gravity (G_S)
Borongan	1.85 kg.	(1.944×10^{-3} m^3)	(9.81 KN/m^3)	1.03
Guiuan	2.00 kg.	(1.944×10^{-3} m^3)	(9.81 KN/m^3)	0.95

This table shows the specific gravity of soil samples from Borongan and Guiuan.

Table 5. Tabular Data of Plastic Limit of Soil Sample from Borongan.

Test No.	weight of crumbled soil thread($W_{a)}$	weight of oven-dried crumbled soil thread($W_{b)}$	plastic limit(PL)	Average(PL)
1	6.81 grams	5.2 grams	30.96%	31.14%
2	6.75 grams	5.14 grams	31.32%	

This table pertains to plastic limit of soil samples from Borongan. Hence soil from Guiuan is cohesionless which has no plasticity; its plastic limit was not computed.

Table 6. Data of Moisture Content

source of soil sample	weight of wet soil (grams)(W_w)	weight of oven dry soil (grams)(W_D)	moisture content (grams)(Mc)
Borongan	300	224.7	33.51%
Guiuan	300	265.8	12.87%

This table shows the moisture content of soil samples from Borongan and Guiuan.

Table 7. Data of Liquid Limit of Soil from Borongan

TEST NO.	No. of blows	weight of wet soil(grams)	weight of oven dry soil(grams)	water content(%)
1	33	9.68	6.54	48.09
2	22	12.89	8.61	49.79
3	17	7.92	5.22	51.83
4	12	8.27	5.37	54.01

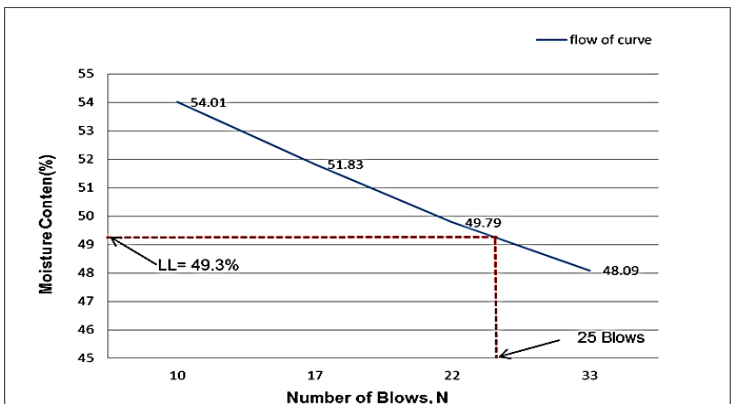

Fig 1: Flow curve for liquid limit test of Soil from Borongan

Table 7 and Figure 1 shows the data and flow curve of liquid limit test where liquid limit was determined.

Table 8. Sieve Analysis of Soil Sample from Borongan

Sieve No.	Sieve Opening (mm)	Mass Retained (grams)	Percentage Retained	Cumulative Percentage Retained	Percentage Passing
3/4"	19	20.05	4.01	4.01	95.99
3/8”	9.50	86.7	17.34	21.35	78.65
# 4	4.75	198.8	39.76	61.11	38.89
# 10	2.00	138.75	27.75	88.86	11.14
# 40	0.425	48.6	9.72	95.58	1.42
# 100	0.150	3.9	0.78	99.36	0.64
# 200	0.075	2.6	0.52	99.98	0.12
Pan	-	0.6	0.12	100.00	0

This table shows the particle distribution of soil sample from Borongan. Through the percentage passing under sieve # 200, the researchers classified the soil as A-2-7 per AASHTO soil classification.

Table 9. Sieve Analysis of Soil Sample from Guiuan

Sieve No.	Sieve Opening (mm)	Mass Retained (grams)	Percentage Retained	Cumulative Percentage Retained	Percentage Passing
3/4"	19	0	0	0	100.00
3/8”	9.50	3.72	0.74	0.74	99.26
# 4	4.75	5.50	1.10	1.84	98.16
# 10	2.00	54.50	10.90	12.74	87.26

# 40	0.425	274.80	54.96	67.7	32.30
# 100	0.150	146.40	29.28	96.98	3.02
# 200	0.075	11.4	2.28	99.26	0.74
Pan	-	3.68	0.74	100.00	0

Table shows the particle distribution of soil sample from Guiuan. Through the percentage passing under sieve # 200 and having no plasticity index the researchers classified the soil as A-3 per AASHTO soil classification.

Table 10. Tabular Representation of Overall Load Bearing Capacity (KN) of Soil Samples from Guiuan

Penetration (mm)	*GCS*			$\bar{X}$		*GT1*			$\bar{X}$		*GT2*			$\bar{X}$
0.64	1	3		*1*		4	1	1	*2*		4	6	8	*6*
1.27	7	4	5	*5*		2	6	9	*9*		4	5	0	*3*
1.91	6	9	7	*8*		0	3	3	*2*		7	9	5	*7*
2.54	3	6	6	*5*		6	8	0	*8*		6	4	2	*4*
3.81	8	0	2	*0*		7	2	8	*9*		5	8	8	*7*
5.08	8	5	7	*7*		2	9	2	*1*		2	5	8	*5*
6.35	4	4	7	*5*		1	6	0	*9*		7	3	8	*6*
7.62	1	3	0	*2*		0	5	4	*3*		0	6	02	*9*
8.69	8	9	9	*9*		09	03	06	*06*		61	65	66	*64*
	GP1			$\bar{X}$		*GP2*			$\bar{X}$					
0.64	5	3	7	*5*		8	6	0	*8*					
1.27	9	1	3	*1*		8	2	7	*9*					

1.91	6	5	7	*6*		1	2	0	*1*		
2.54	1	2	7	*0*		0	7	0	*9*		
3.81	3	8	4	*5*		8	6	3	*9*		
5.08	2	9	6	*9*		01	05	03	*03*		
6.35	0	5	4	*3*		68	70	66	*68*		
7.62	8	8	4	*7*		18	18	21	*19*		
8.69	07	03	05	*05*		64	66	59	*63*		

This table presents the overall bearing test result of soil samples from Guiuan which was conducted at DPWH-Borongan. Numbers 1, 2 & 3 at the axis below Specimen ID denotes for the three samples prepared by the researchers to come up with a mean value of bearing capacity of three samples. The X bar is the mean of all three samples.

Furthermore, the value of the mean was used in order to determine the average value of load bearing capacity of soil samples. To read; at 0.64 mm penetration, GCS - Sample 1 has met a bearing capacity of 11 KN.

Table 11. Tabular Representation of Overall Load Bearing Capacity (KN) ofSoil Samples from Borongan

Penetration (mm)	*BCS*			$\bar{X}$		*BT1*			$\bar{X}$		*BT2*			$\bar{X}$
0.64		2	0	*0*		2	3	1	*2*		5	6	5	*5*
1.27	2	4	3	*3*		0	9	9	*9*		6	4	3	*3*
1.91	6	7	7	*6*		3	4	3	*3*		4	3	5	*4*
2.54	1	0	2	*1*		7	9	8	*7*		0	1	9	*0*
3.81	7	5	6	*6*		2	3	2	*2*		8	6	7	*7*
5.08	2	0	1	*1*		8	8	9	*8*		6	7	5	*6*

6.35	4	3	4	*3*	9	1	0	*0*	9	0	9	*9*
7.62	7	8	8	*7*	3	4	4	*4*	5	4	6	*5*
8.69	0	9	0	*9*	7	6	8	*7*	9	8	8	*8*
	BP1			$\bar{X}$	*BP2*			$\bar{X}$				
0.64	8	9	7	*8*	6	8	7	*7*				
1.27	2	1	1	*1*	0	9	8	*9*				
1.91	1	0	2	*1*	1	0	9	*0*				
2.54	5	4	6	*5*	8	9	0	*9*				
3.81	0	2	1	*1*	9	0	8	*9*				
5.08	2	0	1	*1*	8	6	7	*7*				
6.35	5	4	6	*5*	02	04	05	*03*				
7.62	1	2	0	*1*	07	06	06	*06*				
8.69	4	3	2	*3*	10	12	11	*11*				

This table also presents the overall bearing test result of soil samples from Borongan which was conducted at DPWH-Borongan. Numbers 1, 2 & 3 at the axis below Specimen ID denotes for the three samples prepared by the researchers in order to come up with a mean value of bearing capacity of three samples. The value of the mean was used in order to determine the average of load bearing capacities of soil samples. The $\bar{X}$ bar is the mean value of bearing capacity of all three samples.

Table 12. Tabular Representation of the Mean $\bar{X}$ of Bearing Capacities (KN) of Three Samples for every Specimen from Borongan

Specimen ID	Penetration (mm)								
	0.64	*1.27*	*1.91*	*2.54*	*3.81*	*5.08*	*6.35*	*7.62*	*8.69*

BCS	10	13	16	21	26	31	33	37	39
BT1	12	19	23	27	32	38	40	44	47
BT2	15	23	34	40	47	56	59	65	68
BP1	18	21	31	35	41	51	55	61	63
BP2	37	49	60	69	79	87	103	106	111

This table shows mean of the three samples prepared for every specimen sourced from Borongan.

Table 15. Tabular Representation of the Mean $\bar{X}$ of Bearing Capacities (KN) ofThree Samples for every Specimen from Guiuan

Specimen ID	Penetration (mm)								
	0.64	*1.27*	*1.91*	*2.54*	*3.81*	*5.08*	*6.35*	*7.62*	*8.69*
GCS	11	15	18	25	30	37	45	52	59
GT1	12	19	23	28	35	44	50	56	68
GT2	16	23	27	34	47	65	86	99	164
GP1	15	21	26	30	55	69	83	97	105
GP2	18	29	31	49	79	103	168	219	263

This table shows mean of the three samples prepared for every specimen sourced from Guiuan.

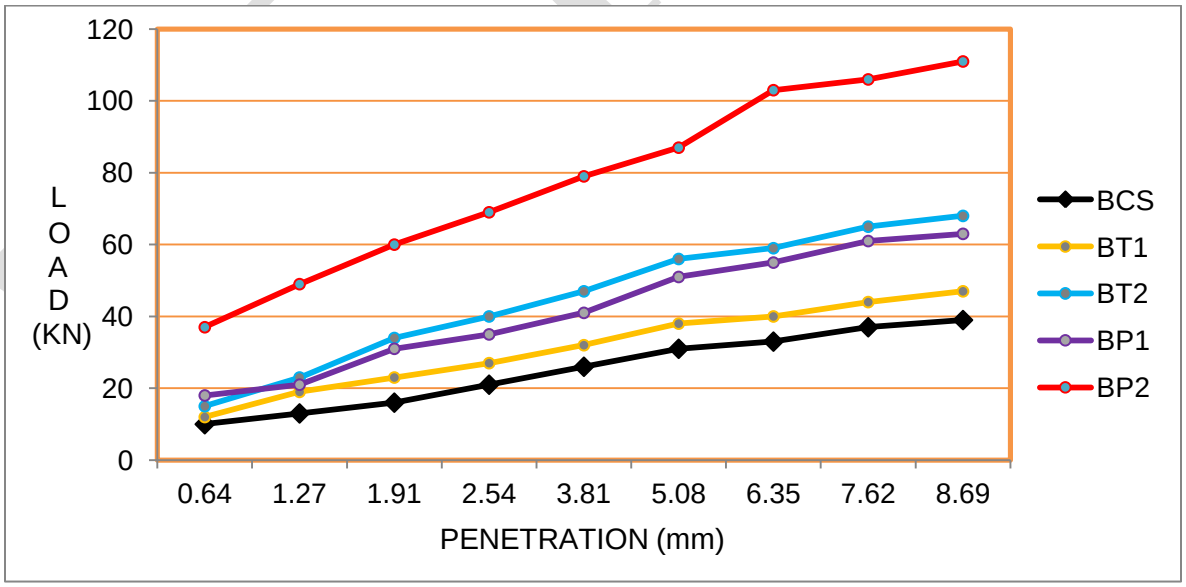

Fig 2: Graphical Representation of Bearing Capacity of Samples from Borongan

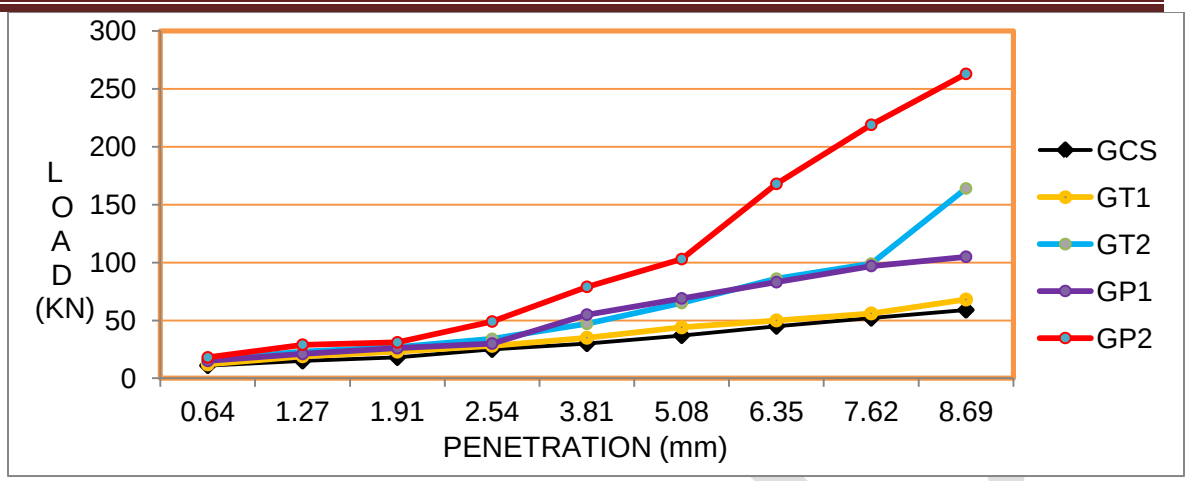

Fig 3: Graphical Representation of Bearing Capacity of Soil Samples from Guiuan

Figure 2 and 3 shows the load bearing capacity of soil samples at every given penetration. Soil samples were tested continuously from 0.64 to 8.69 penetrations. Furthermore, at the same given penetration, shows the differences of load bearing capacity of every soil sample. Hence the difference between data of soil samples (control and with admixtures) from Guiuan and Borongan is not our major concern, their distinction was neglected.

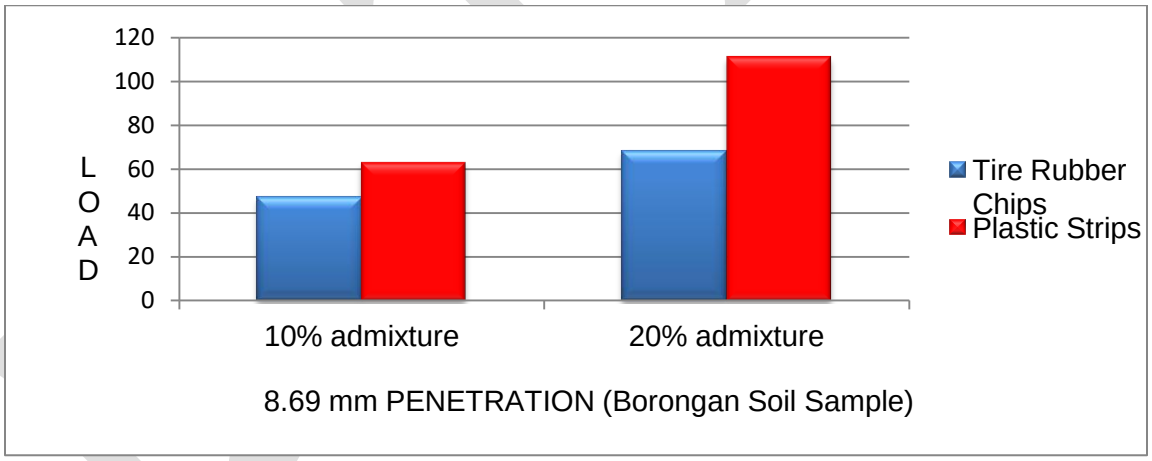

Fig 4: Graphical Representation of the Difference between Tire Rubber Chips and Plastic Strips as Admixture of Soil Sample from Borongan

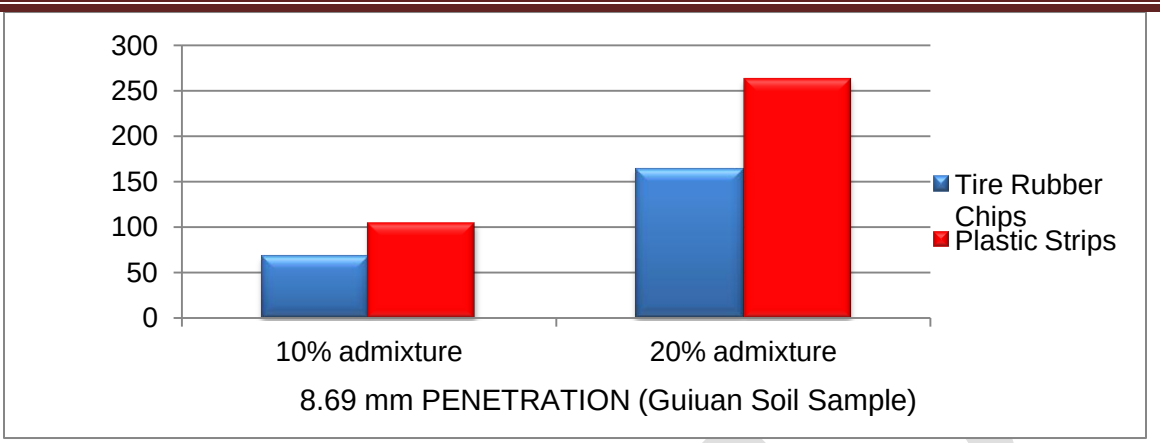

Fig 5: Graphical Representation of the Difference between Tire Rubber Chips and Plastic Strips as Admixture of Soil Sample from Borongan

Figure 5 and 5 shows a simple representation on the difference of bearing capacity between soil samples from Borongan and Guiuan with admixtures of plastic strips and tire rubber chips. 8.69 mm penetration was used in comparing the two samples, which was the highest penetration used in this study.

This tool was used for the reader to easily understand the difference between the two admixtures compared to using of statistical solution which is more complex.

CONCLUSION

The disposal of the wastes without causing any ecological hazards has become a real challenge to the present society. Thus using plastic bottles and tire rubber wastes as a soil stabilizer is an economical and gainful utilization since there is scarcity of good quality soil for embankments and fills. Thus this research is to meet the challenges of society to reduce the quantities of wastes and come up with alternative methods of improving the mechanical property of soil that would lead to the foundation of sustainable society.

Based on the results of this study, the researchers noticed that soil samples with admixtures improved the bearing capacity of soil as compared to control sample. The researchers concluded that Plastic Strips is better admixture than tire rubber chips in improving the soil bearing capacity.

The researchers also concluded that as bearing capacity of soil increases, soil can be stabilized. Readers may be confused; hence we stated the term soil stabilization, for concrete explanation, we only mean to say that adding plastic strips will increase the bearing capacity of soil which will be one way to stabilize the soil. Furthermore, soil stabilization is a broad term that covers lot of ways in order to meet this objective.

RECOMMENDATIONS

After conducting series of experiments, the researchers have drawn findings that plastic strips may have maximum volume need to be used for soil stabilization. Hence, we only used a 20% volume of plastic strips; we cited some recommendations in order to meet certain ideas that may lessen doubts to persons who may use this study in soil stabilization.

1. It is recommend having a related study or research using percentage of plastic strips more than 20% volume as used on this study.

2. In handling specimens; hence the major material of this study is a soil, it is recommended to have an extra care in handling to avoid breaking of samples.

3. For further studies, we also recommend to use digital equipment for bearing capacity testing in order to have a more accurate data and easier process in testing.

4. To have other tests on soil like water absorption, swelling, shear tests, etc. That may affect the cbr of soil samples with plastic strips admixture.

5. To use an equipment or machine in cutting plastic bottles and tire rubber into strips and chips respectively.

6. To acquire soil samples in other place different in this study.

REFERENCE

[1] Venancio I. Besavilla,Jr. *Basic Fundamentals of Foundation Engineering*,Reviewer

[2] DPWH Laboratory Testing Procedures Manual, February 1997

[3] DPWH Standard Specifications Vol. II, 2004

[4] http://en.wikipedia.org/w/index.php?title=Special:Book&
bookcmd=download&collection_id=7e86e023a22f5339&writer=rl&return_to
=Soil+stabilization

[5] En.wikipedia.org/wiki/soil_stabilization

[6] https://www.youtube.com/watch?v=8mdSmB3CtZM (cbr test procedure)

[7] https://www.youtube.com/watch?v=EcXJ961qjGA (atterberg limit)

[7] (http://en.wikipedia.org/wiki/Tire)

[8] http://en.wikipedia.org/wiki/Polyethylene_terephthalate

[9] https://www4.uwm.edu/cbu/Papers/2002%20CBU%20Reports/CBU%202002-06.pdf

[10] http://nbmcw.com/articles/concrete/25795-plastic-mixed-reinforced-concrete-behaviour.html

[11] https://www.google.com.ph/search?newwindow=1&q=tire+rubber&oq=tire+rubber&gs_l=serp.3..0l10.788507.799732.0.801498.17.17.0.0.0.0.1584.3358.5-1j0j1j1.3.0....0...1c.1.53.serp..14.3.3354.2qVcgHYl_Jg

[12] https://www.dli.mn.gov/ccld/PDF/ms_soils_classification_and_bearing_table.pdf