LEC Journal 2023, 5(1): 67-74
ISSN: 2565-5205 (print)

Research Article

Influence of Egg Shell Powder, Bagasse Ash and Lime on Stability of Soil

Bibek Uprety[1]*, Biswas Uprety[2], Ananda Panta[3]

[1]Lumbini Engineering Management and Science College *(Pokhara University)* Rupandehi, Nepal

[2]Geotechnical Engineer, *Sambriddha Aviyanta, Company Pvt. Ltd* Kathmandu, Nepal

[3]Oriental Consultant Company Tokyo Japan

*Corresponding mail:uprety.bibek1@gmail.com

Received: April 6, 2023 Revised: April 13, 2023 Accepted: June 30, 2023

Abstract

Foundation is indispensable part of any civil construction. Construction of building structures and other civil engineering structures such as roadways, railways, waterways, airports, water retaining structures, involve huge human and financial resources and their construction on loose or weak soil is a threat to both humans and the project itself, and can also result into loss of both. Construction on weak soil has been significant challenge for geotechnical engineers since time immemorial, thus various types of soil stabilizers are used to stabilize weak soil whose selection depends upon the availability of the stabilizing material, soil properties, environmental condition, foundation type and the budget of the project. The present study intends to evaluate the influence of mixture of sugarcane bagasse ash (SABS), egg shell powder (ESP) and lime on weak soil so as to stabilize it. The physical properties of original soil sample and aforementioned additives mixed soil sample have been carefully determined by conducting sieve analysis, Atterberg's limit test, direct shear strength, Modified Proctor test, California Bearing Ratio (CBR), specific gravity test and free swell index test. Comparative analysis was carried out among all the samples to determine the optimum percentage of sugarcane bagasse ash, egg shell powder and lime required for the stabilization of the weak soil under study. The use of bagasse ash, eggshell powder and lime showed favorable results when determining the geotechnical properties of various sample mix. Despite decrease in the cohesion and maximum dry density during addition of bagasse only in the sample mix, addition of other additives even in small amount brought positive impact in the results. The value of angle of internal friction increased from 23.24 degrees to 29.08 degrees and cohesion increased from 0.19 kg/cm2 to 0.21 kg/cm2. Similarly maximum dry density also increased form 16.54 kN/m3 to 17.42 kN/m3 and optimum moisture content decreased from 16.26% to 15.76%.

Keywords: Sugarcane Bagasse Ash, Egg Shell Powder, Direct shear strength, California Bearing Ratio, Swelling Index

Introduction

Nepal Soil stabilization is a general term used for any, physical, mechanical, biological or chemical technique used to make soil adapt to meet engineering justifications. Enhancing comprises of increasing the performance of a soil and increasing its bearing capacity so the soil provides a solid base and sub-base for supporting the structure load. Any Geotechnical engineer must have sound knowledge on soil stabilization so that the in-situ soil can support the load of the structure and prevent any deformation and settlement of the structure to avoid financial and human loss.

There are various techniques in practice since old times [1,2,3]. The oldest one known is by a mechanical means known as "Rammed Earth" technique. In this technique the soil was compacted at site with hammer or by rollers to pre-compress the soil to avoid settlement during and after construction. It was followed by addition of lime as a stabilizer, then cement based stabilization was in practice and it still is in many construction activities which provides desirable strength and properties to foundation soil immediately after its application [4,5].

There are been many researches and experiments to stabilize weak soil by considering numerous admixtures. In Nepal even today the cement and lime-based stabilizers are widely used as the best stabilizing materials because of the immediate effect of cement on soil and its easy use and economy and abundancy of lime. But due to the increasing waste and unmanaged disposal of waste causing entire environment pollution, various researches in past few years and have been done on using waste and byproduct of various final products as additives in soil stabilization. This solves the problem of environment pollution and as helps in reducing the cost of the project as well. Recent researches are towards green and sustainable stabilization such that there are no adverse effects on the environment. There are number of waste which are already in practice, most commonly being fly ash, blast furnace slag, rice husk, rubber tire, stone dust, sugarcane bagasse ash, silica fumes etc. Many researches are going on many other waste materials such as egg shell powder, waste glass, etc. These all materials are to be used by replacing in-situ soil in appropriate proportion [6,7].

Methodology

Different research papers, articles and books were studied to study the effects of various additives on the geotechnical properties of the soil. It was found that many additives have positive effects on the soil while some have negative. The percentage content of the additives also had influence in the properties of the soil. This research paper studies the combine effects egg shell powder, sugarcane bagasse ash and lime in the geotechnical properties of the expansive soil. Based upon the objectives of present research suitable techniques were adopted for performing various experiments on virgin soil and soil having stabilizer [5,8,9].

Primary data involves field sampling and laboratory tests of the soil sample to determine various required properties of the sample. All the tests are conducted following Indian Standard codes.

Secondary data involves data and information from local and foreign journals, articles, technical papers, dissertations/thesis, local and foreign documents on standards, specifications, some selected codes of practice, and the internet.

Past studies suggest that the study area Mulapni, Kathmandu lies on colluvium deposit containing top layer of sandy soil followed by silty clay and clayey layer.

For the study, the soil sample was collected at a depth of 1.5m from the ground surface. This is because the top layer is generally disturbed and might give false results about the surrounding soil strata.

Sugarcane bagasse ash for the study was collected from Dakshankali Lakhamari Factory, Kathmandu.

The egg shell powder for the study was collected from KC Poultry farm located at Balaju, The egg shell sample was firstly washed with water then cleaned to remove Albumen layer. The sample was then dried at a temperature of 105-106 degree Celsius for 24 hours in oven to remove moisture. It was then grounded and grounded particles are sieved through 90 microns sieve.

Lime for the study was collected from Chobar Cement Factory who also provided with the general chemical and physical properties of the lime.

Different mix proportion for preparation of various samples is presented in the table below:

Table 1: Mix proportion for sample preparation

Sample type	Original soil (%)	Bagasse ash (%)	Egg shell powder (%)	Lime (%)
Original soil	100	0	0	0
M1	80	20	0	0
M2	75	20	3	2
M3	70	20	6	4
M4	65	20	9	6
M5	60	20	12	8
M6	55	20	15	10
M7	50	20	18	12

Results

III.1Sieve Analysis for gradation of soil

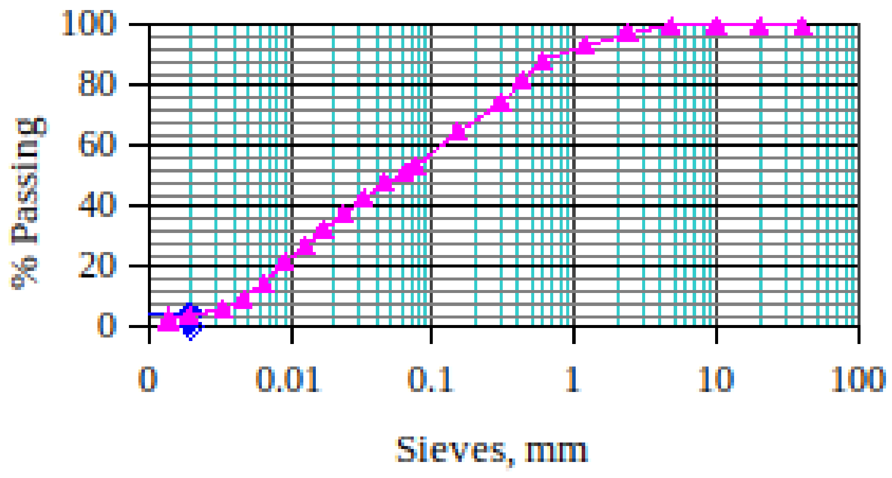

Figure 1: Grain size distribution curve

3.2Atterberg's Limit

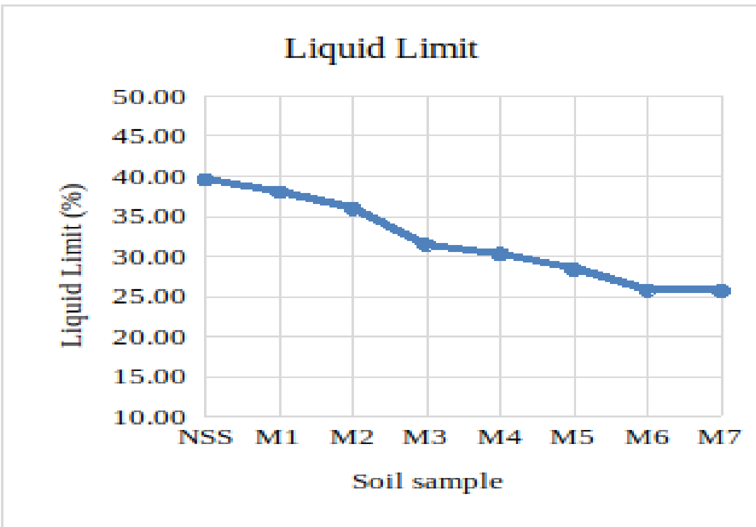

Figure 2: Combined Liquid Limit graph

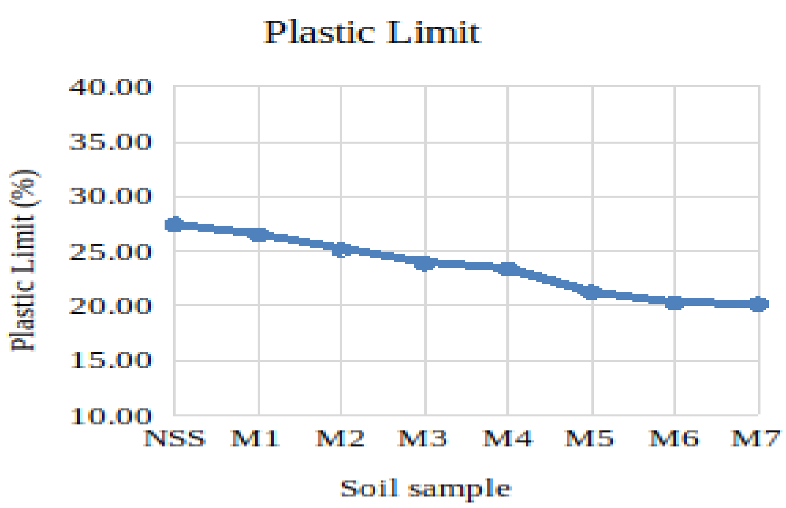

Figure 3: Combined Plastic Limit graph

With the increase in the percentage of additives, both liquid limit and plastic limit decreased. Liquid limit of the natural soil sample was 39.58% and it decreased up to 27.45% at M7 (Soil-52: Bagasse ash-20:Eggshell powder-18:Lime-10). Significant decrease in the liquid limit from 38.03% to 35.90% was seen when 3% eggshell powder was added to the sample keeping percentage of bagasse ash constant at 20%. With further increase in the eggshell powder and 2 % addition of lime, the liquid limit decreased from 35.90% to 31.38%. Both the liquid limit and plastic limit decreased with the increase in the percentage of additives. The value of plastic limit decreased from 27.45% to 20.14%. The decrease in the plastic limit was slight and didn't show any significant decrease in the value. It was also observed that further addition of additives after M6, there was only slight decrease in the liquid limit and plastic limit.

3.3Direct Shear Test

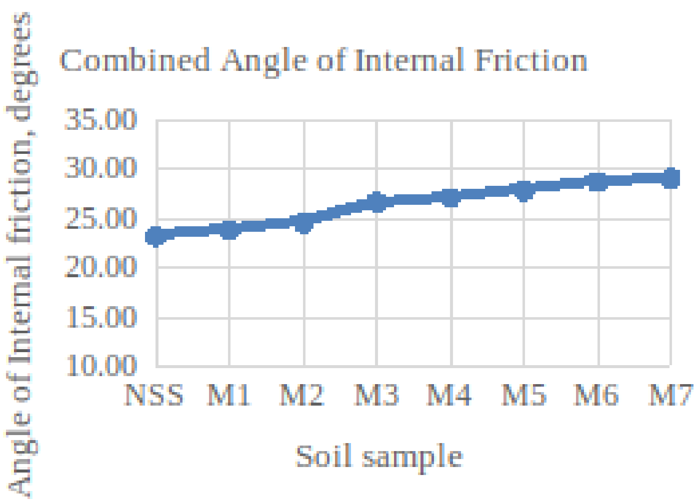

Figure 4: Combined Angle of Internal Friction

From the direct shear test of the natural soil sample and various mix sample it can be observed that the angle of internal friction increased with the increase in the percentage of additives. The angle of internal friction of the natural soil sample was 23.24 degrees and increased up to 29.08 degrees at M7 (Soil-52:Bagasse ash-20:Eggshell powder-18:Lime-10). However, the value of cohesion decreased from 0.19 kg/cm2 to 0.17 kg/cm2 at first when the percentage of bagasse ash was 20%. By adding 3% eggshell powder keeping the percentage of bagasse ash constant at 20%, the value of cohesion decreased from 0.17 kg/cm2 to 0.15 kg/cm2. The value of cohesion started increasing when lime was added in the sample. With 2% addition of lime, cohesion increased from 0.15 kg/cm2 to 0.16kg/cm2 where the percentage of bagasse ash and eggshell powder was 20% and 6% respectively. With further increase in percentage of lime and eggshell powder keeping the percentage of bagasse ash constant at 20%, the value of cohesion increased up to 0.21 kg/cm2.

3.4Modified Proctor Test for MDD and OMC

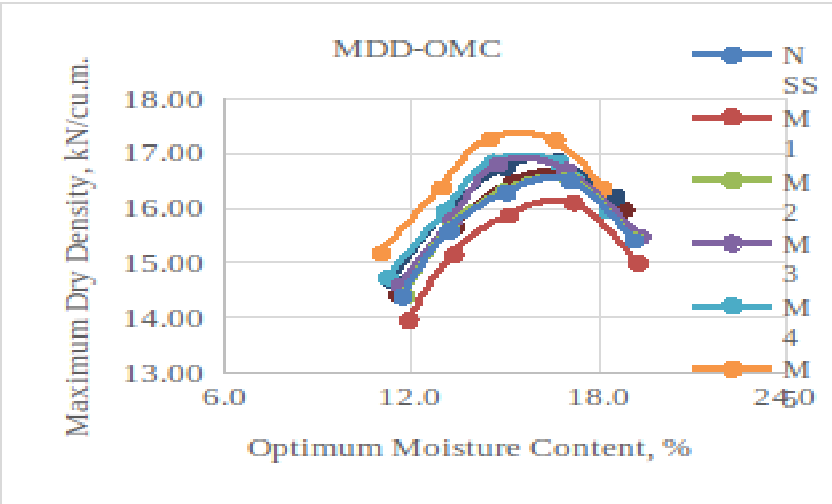

Figure 5: Combined Cohesion

The maximum dry density and optimum moisture content of the original soil sample was found to be 16.54kN/m3 and 16.26% respectively. Maximum dry density peaked at M5 mix at which the optimum moisture content was also the least when compared to other sample mix. The maximum dry density and optimum moisture content of the original soil sample was found to be 17.42kN/m3 and 15.76% respectively,

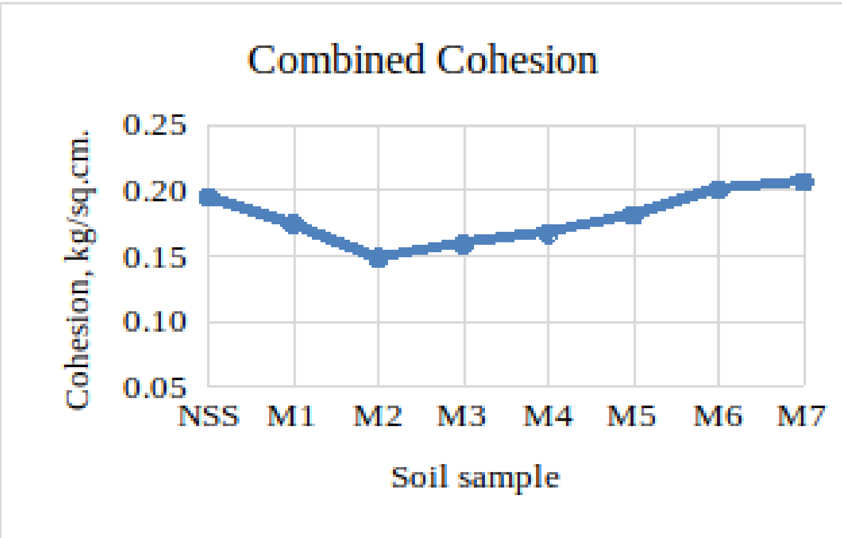

Figure 6: Combined MDD-OMC Graph

It can be observed that the value of maximum dry density decreased from 16.54 kN/m3 to 16.13 kN/m3 when 20% bagasse ash was added in the natural soil sample. At same percentage of bagasse ash the optimum moisture content increased from 16.26% to 16.38%. The value of maximum dry density started increasing when the eggshell powder wad added. At 3% eggshell powder and 20% bagasse ash, the value of maximum dry density increased from 16.13 kN/m3 to 16.58 kN/m3 and optimum moisture content decreased from 16.38% to 16.23%. With addition of 2% lime, increasing the percentage of eggshell powder to 6% and keeping the percentage of bagasse ash constant at 20%, the value of maximum dry density increased from 16.58 kN/m3 to 16.86 kN/m3 and optimum moisture content decreased from 16.23% to 16.11%. The value of maximum dry density peaked to 17.42 kN/m3 at optimum moisture content of 15.76% during M5 (Soil-63: Bagasse ash-20: Eggshell powder-12:Lime-6).

3.5 Specific Gravity

The value of specific gravity increased with the increase in the percentage of additives. The value of specific gravity increased from 2.496 to 2.510 when 20% bagasse ash was added in the natural soil sample. With the addition of 3% eggshell powder keeping the percentage of bagasse ash constant at 20%, the value of specific gravity increased from 2.510 to 2.528. Significant increase in specific gravity from 2.528 to 2579 was noted at M3 (Soil-72: Bagasse ash-20: Eggshell powder-6: Lime-2). After M6 (Soil-57: Bagasse ash-20: Eggshell powder-15: Lime-8), the increase in the specific gravity was very slight relative to the other previous mix sample. The specific gravity increased from 2.632 to 2.637, form M6 (Soil-57: Bagasse ash-20: Eggshell powder-15: Lime-8) to M7 (Soil-52: Bagasse ash-20:Eggshell powder-18:Lime-10).

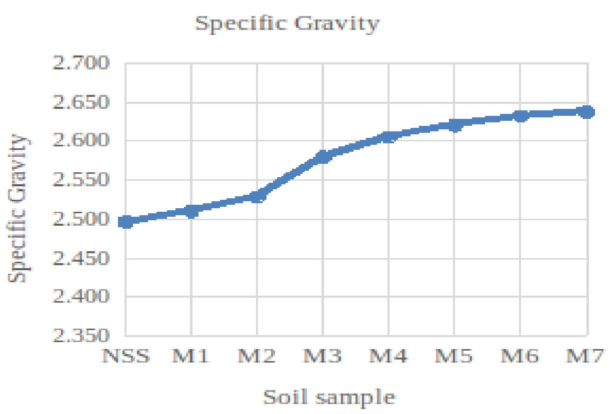

Figure 7: Combined Specific Gravity graph

3.6Free Swell Index

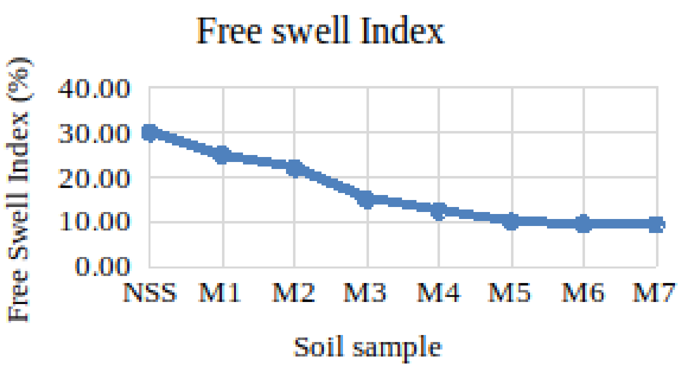

Figure 8: Combined Free Swell index graph

The free swell index of natural soil sample was found to be 30%. According to IS: 1948-1970, it can be categorized under low degree of expansion with non-critical degree of severity.

When 20% bagasse ash was added in the natural soil sample, the free swell index decreased from 30% to 25%. Keeping the percentage of bagasse ash constant at 20% and adding 3% eggshell powder, the value of free swell index decreased from 25% to 22%. Steep gradient in the curve can be seen in the graph above when free swell index decreased from 22% to 15% at M3 (Soil-72: Bagasse ash-20: Eggshell powder-6: Lime-2). After M6 (Soil-57: Bagasse ash-20: Eggshell powder-15: Lime-8), the decrease in the free swell index was very slight relative to the other previous mix sample. The free swell index decreased from 9.5% to 9.3%, form M6 (Soil-57: Bagasse ash-20: Eggshell powder-15: Lime-8) to M7 (Soil-52: Bagasse ash-20: Eggshell powder-18: Lime-10). Free swell index in Alshkane *et al.*, (2020) decreased significantly up to 12% lime and change was very slight when the percentage of lime was more than 12%. In our study, free swell index decreased with the increase in the percentage of additives and change was almost negligible after M6 proportion.

Conclusion

The use of bagasse ash, eggshell powder and lime showed favorable results when determining the geotechnical properties of various sample mix.

a) Despite decrease in the cohesion and maximum dry density during addition of bagasse only in the sample mix, addition of other additives even in small amount brought positive impact in the results.

b) Liquid limit of the natural soil sample was 39.58% and it decreased up to 27.45% at M7 (Soil-52: Bagasse ash-20: Eggshell powder-18: Lime-10). Significant decrease in the liquid limit from 38.03% to 35.90% was seen when 3% eggshell powder was added to the sample keeping percentage of bagasse ash constant at 20%. With further increase in the eggshell powder and 2 % addition of lime, the liquid limit decreased from 35.90% to 31.38%. The value of plastic limit of original soil sample decreased from 27.45% to 20.14% at M7 (Soil-52: Bagasse ash-20: Eggshell powder-18: Lime-10).

c) The value of angle of internal friction increased from 23.24 degrees to 29.08 degrees and cohesion increased from 0.195 kg/cm2 to 0.207 kg/cm2 due to the addition of sugarcane bagasse ash, egg shell powder and lime.

d) Maximum dry density increased form 16.54 kN/m3 to 17.42 kN/m3 and optimum moisture content decreased from 16.26% to 15.76%. With further increase in the percentage of additives after M5 (Soil-63: Bagasse ash-20: Eggshell powder-12: Lime-6), maximum dry density started decreasing and optimum moisture content started increasing.

e) Specific gravity increased of the natural soil sample at 2.496 was increased up to 2.637 at M7 (Soil-52: Bagasse ash-20: Eggshell powder-18: Lime-10). Significant increase could be seen when addition of lime was started.

f) Free swell index also decreased with the increase in the percentage of additives. The value of free swell index of original soil sample decreased from 30 to 9.3 when the proportion was M7 (Soil-52: Bagasse ash-20: Eggshell powder-18: Lime-10).

g) It can be concluded that with the increase of the additives up to certain percentage brings positive influence in the geotechnical properties of soil and after further addition of additives, either there is slight to negligible change in the result or gives unfavorable result.

h) Although egg shells and sugarcane bagasse ash are used in agriculture and animal husbandry in small scale, they are still regarded as wastes in many parts of the country and their production is in large scale. Therefore, they are abundantly available at low costs and even at free of cost in some parts of the country. Lime are also easily available in the market which are cheaper compared to traditional soil stabilizing materials. Using such materials in soil stabilization reduces the cost of the stabilizing work and project as a whole.

i) Being organic materials and because of their decomposing nature, egg shell and sugarcane bagasse ash can be used as environment friendly stabilization material.

j) Egg shells as well as sugarcane bagasse ash are dumped and unutilized and regarded as waste in large extent. The use of egg shell powder and bagasse ash as a soil stabilizing material can aid in reducing the environmental and health problems and also helps in reducing the cost of stabilization work and the project as a whole when used as a stabilizer.

References

[1] O. Amu, A. Fajobi and B. Oke, "Effect of Eggshell Powder on the Stabilizing Potential of Lime on an Expansive Clay Soil," *Journal of Applied Sciences*, (2005)

[2] J. Martirena, B. Middendorf, M. Gehrke and H. Budelmann, "Use of Wastes of the Sugar Industry as Pozzolana in Lime-Pozzolana Binders: study of the reaction", *Cement and Concrete Research*, **28**(11), 1525-1536 (1998).

[3] G. Moses and K. Osinubi, "Influence of Compactive Efforts on Cement Bagasse Ash Treatment of Expansive Black Cotton Soil", *World Academy of Science, Engineering and Technology International Journal of Civil and Environmental Engineering*, **7**(7) 566-573(2013).

[4] S. Anoop, H. Beegom, J. Johnson, J. Midhula, T. Muhammed and S. Prasanth, "Potential of Egg Shell powder as replacement of lime in soil stabilization", *International journal of Advance Engineering Research and Sciences (IJAERSO)*, **4**(8) 86-88 (2017).

[5]A. Negi, "Soil Stabilization using lime", *International Journal of Innovative Research in Science, Engineering and Technology*, ISSN: 2319-88759,2(2), 448-453 (2013).

[6] E. Nyanksol, B. Agyei, E. Annanl, *et al.*. "Characteristics of Stabilized Shrink-Swell deposits using Egg shell Powder", *Global Journal of Engineering, Design and Technology*, **2**(3), 1-7(2013).

[7] N. Pauzi, M. Aziz, M. Ismail and H. Omar, "Waste Soil Improvement Using Egg Shell Powder and Lime at Open Dumping Area", *International Journal of Civil Engineering and Technology (IJCIET)*, **10**(4), 268-277(2019).

[8] R. Ramirez, P. Garcia, J. Reyes, D. Juarez and Y. Ponce, "Use of sugarcane bagasse ash and lime to improve the durability and mechanical properties of compacted soil blocks" *Construction and Building Materials*, **34**,296-305 (2012)

[9] K. R. Arora, Soil Mechanics and foundation Engineering. Delhi: Standard Publishers Distributors, (2000).