ISSN No:-2456 –2165

Statistical Modelling on Stabilization of Compressible Soil in Nilgiris Region

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Abstract— Construction on compressible soil is a great challenge in the field of Geotechnical Engineering. Since there is a reduction in sites for construction development it is crucial to find ways for soil improvement technique to respond to the demands and also by considering the cost and the effect to the environment. The present study is focused to overcome the problems experienced in Nilgiris region. This research work presents the efficiency of stabilization of compressible soil in the Nilgiris region, with the utilization of chemicals such as NaCl, CaCl2 & Ca(OH)2 in various proportions such as 5% , 10% , 15% , 20% and 25% and polypropylene waste fibre material as soil stabilizer in the ratio of 0.2% The strength of treated soil sample is being analysed using the Unconfined Compression Strength (UCC) test and California Bearing Ratio(CBR) test. The strength of the soil is significantly increased with the use of additives such as chemicals and polypropylene waste fibre materials. The results obtained from both process are used in regression modelling to arrive an empirical correlation between the load and settlement, strain and stress.

Keywords—Compressible Soil, Stabilization, Regression Modelling, Compressive Strength.

I. INTRODUCTION

The compressible soils are high water holding capacity in nature, low specific gravity and medium to low permeability. Many engineering problems in the form of slope instability, bearing capacity failure or excessive settlement could occur either during or after the construction phase due to low shear strength and high compressibility of this soil. By stabilization techniques the load bearing capacity under structures is being increased. It also increases the unconfined compressive strength and reduces initial permeability of the stabilized soil. However, recent technology has increased the number of traditional additives used for soil stabilization purposes. The selection of sodium chloride and calcium chloride as chemical additive helps to provide better results and cheaper than any other chemicals. Using plastics as soil stabilizer helps us to reduce the problem of disposing the plastic as well as increases the density and California Bearing Ratio (CBR) of soil in an economical way. Regression analysis helps to understand how the typical value of the dependent variable (or 'criterion variable') changes when any one of the independent variables is varied, while the other independent variables are held fixed. Hence it helps in obtaining an empirical correlation has to establish a relationship between load & penetration and stress & strain.

II. MATERIALS AND METHODOLOGY

In the current study the soil is selected as compressible soil and the stabilizing agents used are of NaCl, CaCl2 & Ca(OH)2 and polypropylene waste plastic.

A. Properties of Additives

The properties of the additives used are tabulated below.

S. No	Properties	Sodium Chloride	Calcium Chloride	Hydrated Lime	Polypropylene waste plastic
1	Chemical formula	NaCl	CaCl2	Ca(OH)2	(C3H6)n
2	Molar Mass	58.44 g/mol	110.98 g/mol	74.093 g/mol	42.07 g/mol
3	Melting point	801° C	782° C	580° C	130 to 171° C
4	Density	2.17 g/cc	2.15g/cc	2.211g/cc	0.946 g/cc
5	Type of bond	Ionic bond	Ionic bond	Ionic Bond	Adhesive bond

Table 1: Properties of Additives

B. Summary of the Laboratory Investigations

From the laboratory investigations the following properties of the soil sample are determined and they are tabulated as below:

ISSN No:-2456 –2165

S.No	Properties	Values
1	Moisture Content	25%
2	Specific Gravity	2.27
3	Uniformity Coefficient	17.64
4	Coefficient of Curvature	0.24
5	Organic Content	16%
6	Liquid Limit	60%
7	Plastic Limit	17.15%
8	Optimum Moisture Content	14%
9	Maximum Dry Density	1.4 g/cc
10	Free Swell Index	9.09
11	UCC	124 KPa
12	CBR @ 2.5mm Penetration	1.92
13	CBR @ 5mm Penetration	1.85

Table 2: Properties of the Soil Sample

III. DETERMINATION OF STRENGTH OF SOIL USING ADDITIVES

Due to the high water holding capacity in nature, low specific gravity and medium to low permeability, the compressible soil faces many engineering problems due to its low shear strength. The load bearing capacity under structures and the unconfined compressive strength of the soil is increased by stabilization techniques. Also the stabilized soil, reduces the initial permeability in it. The additives which are used as soil stabilizer are NaCl, $CaCl_2$, $Ca(OH)_2$ and 0.2% of polypropylene plastic waste and their properties are discussed in the previous chapter.

A. Unconfined Compression Test Using NaCl, $CaCl_2$ and $Ca(OH)_2$

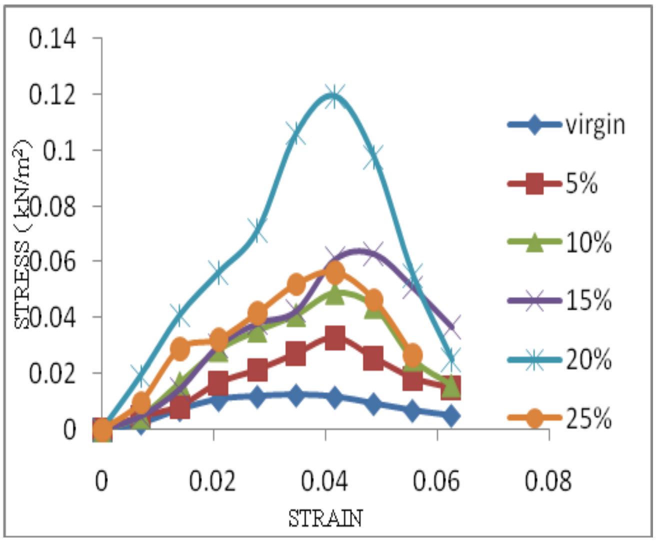

Fig.1 Stress Strain Curve for Virgin Soil and Various Concentrations of NaCl, $CaCl_2$ & $Ca(OH)_2$

The stress strain curve for virgin soil and various concentrations of NaCl, $CaCl_2$ and $Ca(OH)_2$ has been drawn. From the graph it is clearly inferred that the compressive strength of the soil has been increased from 124 Kpa (virgin soil) to 1196 Kpa (treated soil) and the maximum strength of the soil is being attained at 20% of additives.(Ref Fig 1)

B. Unconfined Compression Test Using NaCl, $CaCl_2$ and $Ca(OH)_2$+0.2 % of Plastic Waste

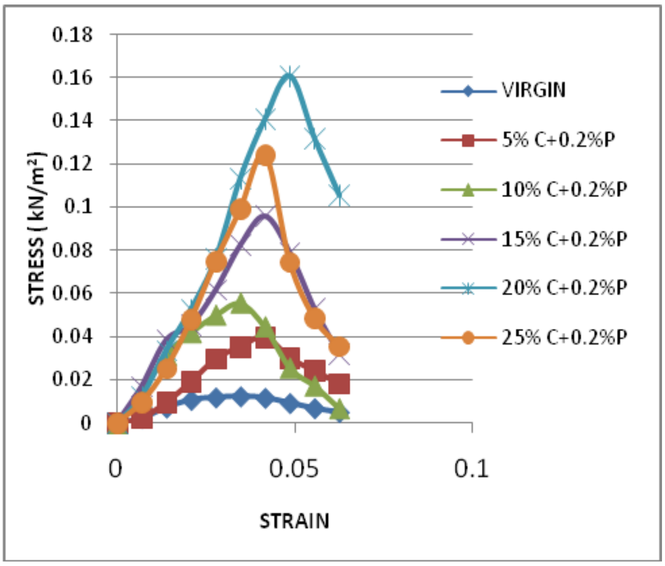

Fig.2 Stress Strain Curve for Virgin Soil and Various Concentrations of NaCl, $CaCl_2$ & $Ca(OH)_2$ +0.2 % of Plastic Waste

C. California Bearing Test Using NaCl,$CaCl_2$ and $Ca(OH)_2$+0.2 % Plastic Waste

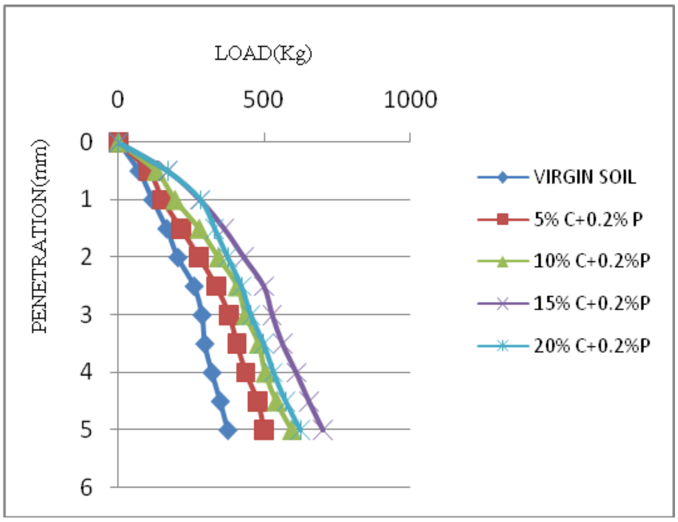

Fig.3 Load Displacement Curve for Virgin Soil and Various Concentrations of Nacl, Cacl2 &Ca(OH) 2 + 0.2% of Plastic Waste

From the graph(Fig 3), it is being inferred that the CBR value has been increased significantly on the addition of additives to the sample and attains the maximum CBR value of 3.7 at 2.5mm penetration and 3.47 at 5mm penetration. This maximum CBR value is attained at the addition of 15% of chemicals and 0.2% of waste plastic.

D. Regression Modelling

There are different methods of regression modelling, each method of modelling has its own advantages and disadvantages. For the current study Simple Linear Regression modelling and Polynomial Regression modelling are carried out by considering Load and Strain as Independent variable and Displacement and Stress as Dependent variable.

E. Regression Modelling by Data Analysis Tool

The regression modelling is further carried out using a data analysis software package. The most common data analysis software package is MS-EXCEL. The trend line tool in MS-EXCEL is used for this purpose.

Simple Linear Regression analysis was carried out for the stress strain value of 20% of NaCl, $CaCl_2$ & $Ca(OH)_2$ + 0.2% of plastic waste by MS-EXCEL trend line tool.(Ref Fig 4)

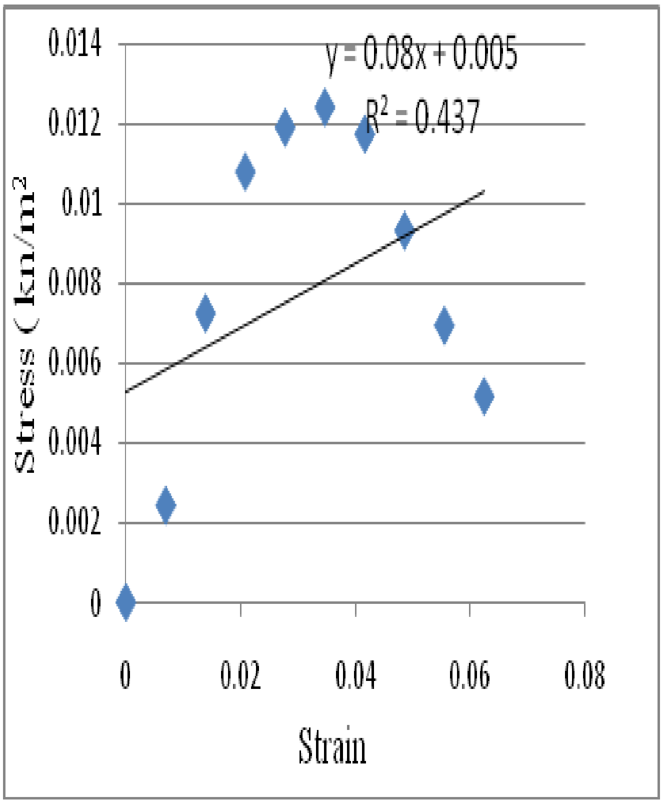

Fig.4 Linear Trendline for stress strain value of 20% of NaCl, $CaCl_2$ & $Ca(OH)_2$ + 0.2% of Plastic Waste

The correlation obtained is **y** = 0.08x + 0.005 and R^2 = 0.437 Simple polynomial Regression analysis was carried out for the stress strain value of 20% of NaCl, $CaCl_2$ & $Ca(OH)_2$ + 0.2% of plastic waste by MS-EXCEL trend line tool. (Ref Fig 5)

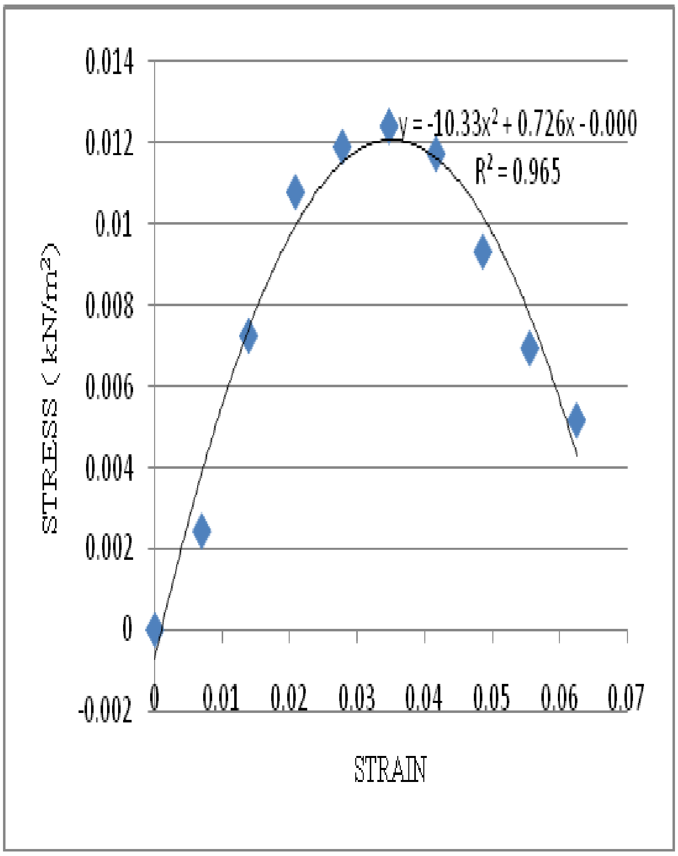

Fig.5 Polynomial Trendline for Stress Strain Value of 20% of NaCl, $CaCl_2$ & $Ca(OH)_2$ + 0.2% of Plastic Waste
The Correlation Obtained is $y = -10.33x^2 + 0.726x - 0.000$ and $R^2 = 0.965$

SOIL	CORRELATIONS	R^2 VALUE
Virgin soil	$y = -75.58x^2 + 5.657x - 0.019$	0.805
5% of NaCl, $CaCl_2$ and $Ca(OH)_2$ + 0.2% of plastic waste	$y = -84.52x^2 + 6.145x - 0.016$	0.832
10% of NaCl, $CaCl_2$ and $Ca(OH)_2$ + 0.2% of plastic waste	$y = -61.89x^2 + 4.669x - 0.010$	0.879
15% of NaCl, $CaCl_2$ and $Ca(OH)_2$ + 0.2% of plastic waste	$y = -24.68x^2 + 1.969x - 0.006$	0.885
20% of NaCl, $CaCl_2$ and $Ca(OH)_2$ + 0.2% of plastic waste	$y = -10.33x^2 + 0.726x - 0.000$	0.965
25% of NaCl, $CaCl_2$ and $Ca(OH)_2$ + 0.2% of plastic waste	$y = -49.74x^2 + 3.166x - 0.001$	0.940

Table 3: Summary of the Correlations

Simple Linear Regression analysis was carried out for the load displacement value of 15% of NaCl, $CaCl_2$ & $Ca(OH)_2$ by MS-EXCEL trend line tool. (Ref Fig 6)

ISSN No:-2456 –2165

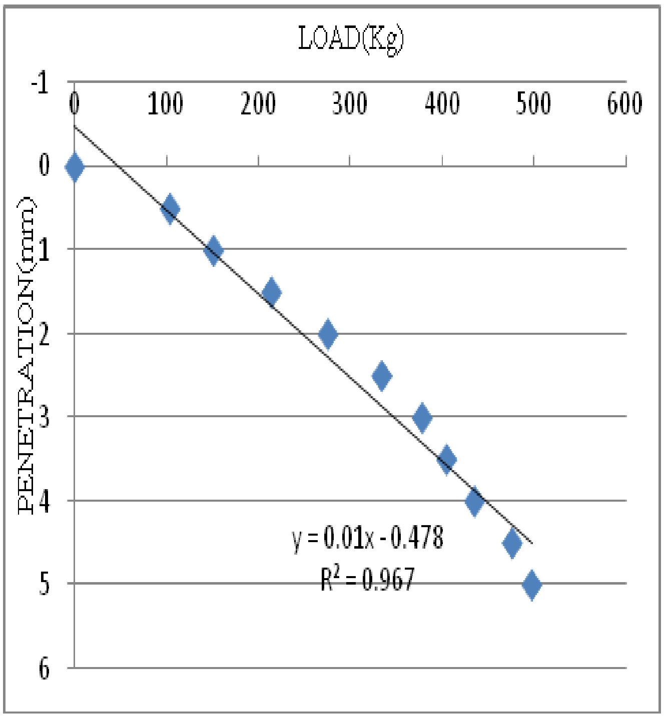

Fig.6 Linear Trendline for Load Displacement Value of 15% of Nacl, $Cacl_2$ & $Ca(OH)_2$ + 0.2% of Plastic Waste The Correlation Obtained Is Y = 0.01x - 0.478 And R^2 = 0.967

Simple Polynomial Regression analysis was carried out for the load displacement value of 15% of NaCl, $CaCl_2$ & $Ca(OH)_2$ by MS-EXCEL trend line tool.(Ref Fig 7)

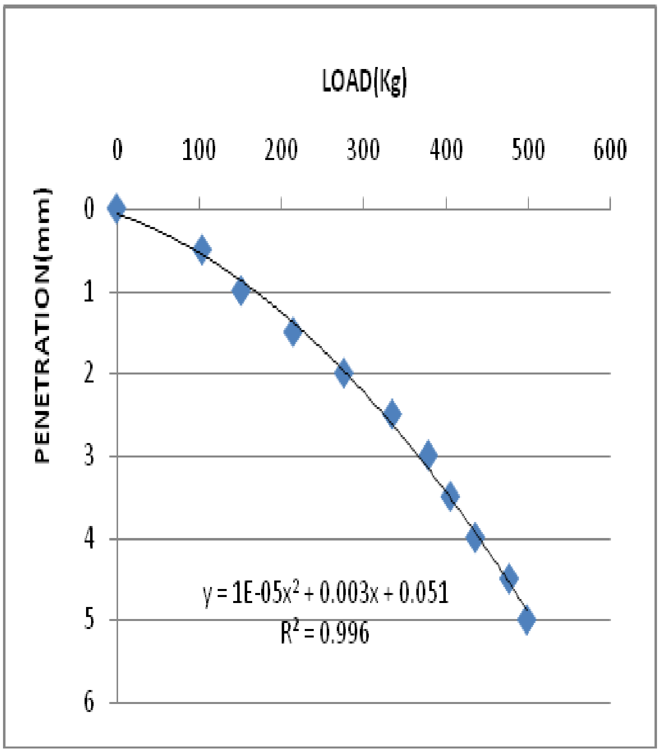

Fig.7 Polynomial Trendline for Load Displacement Value of 15% of NaCl, $CaCl_2$ & $Ca(OH)_2$ + 0.2% of plastic waste The Correlation Obtained is y = 1E-05x^2 + 0.003x + 0.051 and R^2 = 0.996

SOIL	CORRELATIONS	R^2 VALUE
Virgin soil	y = -16.96x^2 + 192x + 54.99	0.972
5% of NaCl, $CaCl_2$ and $Ca(OH)_2$ + 0.2% of plastic waste	y = -21.36x^2 + 232.7x + 40.89	0.986
10% of NaCl, $CaCl_2$ and $Ca(OH)_2$ + 0.2% of plastic waste	y = -15.77x^2 + 188.4x + 20.96	0.993
15% of NaCl, $CaCl_2$ and $Ca(OH)_2$ + 0.2% of plastic waste	y = -12.06x^2 + 157.0x + 10.62	0.997
20% of NaCl, $CaCl_2$ and $Ca(OH)_2$ + 0.2% of plastic waste	y = -9.657x^2 + 119.8x + 6.583	0.995

Table 4: Summary of the Correlations

IV. SUMMARY AND CONCLUSIONS

The unconfined compressive strength of the soil was found to be varied with different concentrations of NaCl, $CaCl_2$ and $Ca(OH)_2$ and 0.2% of plastic waste. And also it was found that, at 20% of chemical additives + 0.2% plastic waste it gives maximum strength of 1606 Kpa than any other concentrations.

From the CBR test it can be concluded that the strength of the soil gets increased from varying concentrations of NaCl, $CaCl_2$ and $Ca(OH)_2$ and 0.2% of plastic waste. It was also found that at 15% of chemical additives + 0.2% plastic waste, it gives maximum CBR values of about 3.7 and 3.47 at 2.5mm and 5mm penetrations respectively.

During regression modelling an empirical correlation have been formed to establish a relationship between load & penetration and strain & stress.

Based on the R^2 values the polynomial regression was adopted for both UCC and CBR tests. As a result of polynomial regression which has been carried out for the UCC test, the correlation y = -10.33x^2 + 0.726x - 0.000 was obtained at 20% of chemical additives + 0.2% plastic waste which gives the best fit to the soil (R^2 = 0.965).

As a result of polynomial regression which has been carried out for the CBR test, the correlation y = -12.06x^2 + 157.0x + 10.62 was obtained at 15% of chemical additives + 0.2% plastic waste which gives the best fit to the soil (R^2 = 0.997).

Based on the obtained results and discussions the following conclusions can be made for compressible soils.

The soil sample attain its maximum strength in the addition of 20% of chemicals and 0.2% of plastic waste for UCC and 15% of chemicals and 0.2% of plastic waste for CBR.

Utilization of the polypropylene materials for the stabilization of soil, which will directly help in decreasing the requirement of the disposal and also decline the hazardous environmental impacts.

The empirical correlation obtained from the above study have a R^2 value near to one which implies that the empirical correlations fits best to the actual field conditions.

REFERENCES

[1]. Shish Pal, Vinod Kumar Sonthwal, Jasvir S Rattan "Review on Stabilisation of Soil Using Polypropylene as Waste Fibre Material International", Journal of Innovative Research in Science, Engineering and Technology Vol. 4, Issue 11, November 2015.
[2]. Dhiaadin Bahaadin Noory Zangana "The Effect Of Sodium Hydroxide On The Strength Of KirkukSoil – Cement Mixtures" ,Anbar Journal for Engineering Science.
[3]. Olaniyan, O.S., Olaoye, R.A, Okeyinka, O.M, and Olaniyan, D.B "Soil Stabilization Techniques Using Sodium Hydroxide Additives", International Journal of Civil Environmental Engineering IJCEE-IJENS Vol: 11 No: 06.
[4]. Md. Shakeel Abid "Stabilization of Soil using Chemical Additives", GRD Journals- Global Research and Development Journal for Engineering, Volume 1, Issue 12 ,November 2016.
[5]. V. Mallikarjuna, T. Bindu Mani "Soil Stabilization using plastic waste", International Journal of Research in Engineering and Technology.
[6]. Consoli, N.C., Prietto, P.D.M. and Ulbrich, L.A., "The behaviour of fibre- renforced cemented soil" Ground Improvement, London, 3(1), pp21-30, 1999.
[7]. Yetimoglu, T., Inanir, M., O.E., "A study on bearing capacity of randomly distributed fiber-reinforced sand fills overlying soft clay" Geotextiles and Geomembrane 23(2), pp174-183, 2005.
[8]. Ingles, O.G. and J.B. Metcalf, "Soil Stabilization", Chapter 4 and 7, Butter WorthsBools Company, 1972.
[9]. Moh, Z.C., "Soil Stabilization with Cement and Sodium Additives", Journal of Soil Mechanics and Foundation Division, ASCE, Vol. 88, No. SM6, Dec. 1962.
[10]. ASTM Standards on Soil stabilization with Admixtures, 2nd Edition, 1992, 126 pp.
[11]. Maha Hatem Nsaif, "Behavior of Soils Strengthened By Plastic Waste Materials", Proceedings of Indian Geotechnical Conference December 15-17,2011, Kochi (Paper No. H-304).
[12]. K.V. Madurwar, P.P. Dahale, "Comparative Study of Black Cotton Soil Stabilization with RBI Grade 81 and Sodium Silicate", International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 2, February 2013.
[13]. Consoli, N. C., Montardo, J. P., Prietto, P. D. M., and Pasa, G. S., "Engineering behavior of sand reinforced with plastic waste", Journal of Geotechnical and Geoenvironmental Engineering. Vol. 128 No. 6, 2002, pp, 462-472.
[14]. Tang, C. S, Shi, B., Gao, W., Chen, F. J., and Cai, Y., "Strength and mechanical behavior of short polypropylene fiber reinforced and cement stabilized clayey soil". Geotextiles and Geomembranes, Vol. 25, 2007, pp, 194–202.
[15]. Anas ashraf, arya sunil, "Soil Stabilisation using raw plastic bottles", Journal of Engineering and Development, Vol. 17, No.4, October 2013, ISSN 1813-7822.