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An Experimental Study on Soil Stabilization with Water Resistance

B.Veera Siva Prasad[1], B.Ganesh[2]
[1]M.tech student Roll no- 17961D1909, Lenora Engineering College, Rampa chodavaram, E.G.Dist, AP, India.
[2] Assistant Professor, Department of Civil Engineering, Lenora Engineering College, Rampachodavaram, E.G.Dist, AP, India
**Corresponding Author: B.Veera Siva Prasad*

Abstract: *construction and subsequent maintenance of pavements in good condition has become quite problematic During monsoon season the natural subgrade soils become soft and pose serious problems ,To the movement of vehicular traffic, Instead of cutting out and replacing the unstable soil, soil adjustment is the only alternative as it saves lot of time and millions of money too. Soil adjustment can be defined as the change of the soil properties by synthetic or physical means keeping in mind the end goal to improve the designing nature of the soil. This work presents the result of comprehensive laboratory investigation over behaviour of stabilized loose soft soil using Terassil and Zycobond as nano-chemical based stabilizer. The soil is stabilized in different proportions and combination of Terassil and Zycobond along with cement*

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I. Introduction

In India, since last two decades, tremendous increase in infrastructure development has been taking place. As part of it, the development of pavements is taking place at a rapid pace. In the process, many a times, the pavements need to be laid on soft and un-favorable grounds, As California Bearing Ratio (CBR) value of such type of subgrade soils is very low due to which the thickness of pavement layers increases. This in turn requires large quantities of natural materials leading to depletion of valuable natural resources. Hence, of thickness of pavement layers by enhancing the CBR value of subgrade amounts to sustainable development, which is much desirable in a country like ours. At times, construction on such grounds may lead to distresses arisen from low shear strength, substantial total and differential settlement, excessive seepage and liquefaction. Conversion of locally available difficult soil into suitable construction material would be an economical solution.

For many decades, Engineers and Researchers have attempted to solve problems posed by various types of soft grounds. Due to various reasons and there may be need to improve their strength and durability.When poor quality soil is encountered at construction site, the structure can be designed accordingly or the unsatisfactory soil can be replaced with a suitable soil borrowed from nearby area. Another option is to modify the properties of the existing soil so that it meets the design requirements. This last alternative has led to the development of soil stabilization techniques. Soil stabilization methods using locally available cheaper materials have considerable scope in reducing the initial construction cost of the pavements

But the various developmental activities necessitate making use of these lands, which are not having the desirable properties as an engineering material. The most frequent use of soil stabilization is in relation to the formation of sub-grades and sub-bases for road construction. Continued efforts are being made to improve the weak soil and hence its CBR values. Over the years engineers have tried different methods to stabilize soils that are subject to fluctuations in strength and stiffness properties as a function of fluctuation in moisture content. Soil stabilization is a process of improving the engineering properties of the soil. Stabilization can be derived from thermal, electrical, mechanical or chemical means. The first two options are rarely used. Chemical stabilization involves mixing or injecting the soil with chemically active compounds such as Portland cement, lime, fly ash, calcium or sodium chloride or with viscoelastic materials such as bitumen. These additives are considered as chemically active additives since they react with soils forming cementing compounds. Chemical stabilizers can be broadly divided into two groups viz., the traditional stabilizers such as hydrated lime, Portland cement and Fly ash and the non- traditional stabilizers comprised of sulfonated oils, ammonium chloride, enzymes, polymers, and potassium compounds. Among these, the most widely used chemical additives are lime, Portland cement and fly ash, blast furnace slag. Cement stabilization has been widely used to improve soft soils and grounds. Many researches have focused on study of the properties of the cement stabilized soil. The main purpose of this research is to improve the CBR characters of the soft loose soil.

problem of loose sandy soil

The main problem encounter with loose soft soils is that they are poor in engineering properties. These soils are easily drained, they do not maintain a proper moisture content. These soils have less density and low shear strength. If road embankment is beside of a canal , then there is a problem of reaching of water to its subgrade by means of seepage. This leads to damage of entire roads.

Aim and objective

Main objective of this experimental study is to investigate the effect of Zycobond and Terrasil along with cement on geotechnical properties of soft loose sandy soil . By adding terrasil it improves water resistance while zycobond provides fatigue resistance to cement stabilization.

- To improve MDD and decrease OMC
- To improve CBR values

II. Literature Review

Aparna Roy (2014) studied the high plasticity soft soil stabilized with different percentages of Rice Husk Ash and a small amount of Cement. Observations are made for the changes in the properties of the soil such as MDD, OMC, CBR and UCS. The results obtained show that the increase in RHA content increases the OMC but decreases the MDD. Also, the CBR value and UCS of soil are considerably improved with the RHA content. From the observation of maximum improvement in strength, 10% RHA content with 6% cement is recommended as optimum amount for practical purposes by observing the tremendous improvement of CBR Value of soil.

Norazlan Khalid et al. (2014) studied the effectiveness of using mixtures of lime with palm oil fly ash (LimePOFA) in soft soil stabilization was investigated by mean of laboratory testing to evaluate the California Bearing Ratio (CBR) value. The Palm Oil Fly Ash (POFA) additives used is a finely waste product material from the process of burning palm oil fibre. The POFA used is classified as Class-F fly ash accordingly to ASTM C618 and described as siliceous and aluminous materials with possess little or no cementitious value. The optimum of 6% hydrated lime used their study as an active additive to the various % mixtures of POFA for the pozzolanic reaction. The result shown that the mixing of 6% Lime with 3% POFA was giving the higher CBR value for soaked and unsoaked condition. It shows the POFA can be used as additives to stabilized soft soil subgrade.

LEKHA B.M, et al. (2013) studied the behaviour of Black Cotton (BC) soil with and without chemical stabilizer. Terrasil was used as stabilizer and it was used for different dosages and cured for 7, 14 and 28 days . Due to the chemical reaction, the soil mass densifies by minimizing the voids between particles and it makes the soil surface impervious. The chemical compositions and microstructures of soils were analyzed using X Ray Diffraction (XRD) and Scanning Electron Microscope (SEM) respectively.

Keerthi.Y, et al. (2013) studied the stabilization of clayey soil using cement kiln waste and established that the chemical compounds found in soil; quartz, feldspar, dolomite, calcite, montmorillonite, kaolinite etc. react with the chemical constituents found in different identified chemical stabilizers .Soil containing different properties in various percentages is mixed with CKD (Cement Kiln Dust) in different proportions and parameters like dry density and moisture content are found out. After examining the values obtained ideal values are obtained at 50% proportional mix of CKD in total percentage.

Gundaliya.P.J, Ozaa J.B (2013) studied BC Soil tested using three different stabilizing agents - 1.Cement waste dust collected from the cement plant 2. Cement Dust + Lime Powder 3. Lime Powder. The cement waste dust was found best agent as a stabilizer to improve the Atterberg's Limit and hence Plasticity Index of BC Soil as well as the compressive strength of the same. Laboratory tests were performed with different percentages of three stages, each of them ranging from 1% to 9%. The behaviour of BC Soil of Rajkot region was improved with stage no. 1, the percentage of Cement dust 7% of Cement dust in BC Soil is looking to be the appropriate mixing. Also in second stage, improvement is shown at 8% of combination of cement dust and Lime powder. Third stage was observed a best suited result at 9% of Lime powder in BC Soil. They concluded after obtaining results in laboratory under standard conditions to use the Cement dust as a stabilizing agent for the purpose to improve Plasticity Index of BC Soil compare to other two combinations.

Degirmenci et al. (2007) investigated phosphogypsum with cement and fly ash for soil stabilization. Atterberg limits, standard Proctor compaction and unconfined compressive strength tests were carried out on cement, fly ash and phosphogypsum stabilized soil samples. Treatment with cement, fly ash and phosphogypsum generally reduces the plasticity index with increase in MDD with cement and phosphogypsum contents, but decreased as fly ash content increased. The OMC decreased and UCS increased with addition of cement, fly ash and phosphogypsum.

Amu et al. (2005) studied cement and fly ash mixture for stabilization of expansive clayey Soil. Three different classes of sample (i) 12% cement, (ii) 9% cement + 3% fly ash and (iii) natural clay soil sample were tested for maximum dry densities (MDD), optimum moisture contents (OMC), California bearing ratio (CBR), unconfined compressive strength (UCS) and the Undrained Triaxial tests. The results showed that the soil sample stabilized with a mixture of 9% cement + 3% fly ash is better with respect to MDD, OMC, CBR, and shearing resistance compared to samples stabilized with 12% cement, indicating the importance of fly ash in improving the stabilizing potential of cement on expansive soil.

Summary

By observing the following papers we adopt following procedure:

- We are decided to adopt chemical stabilization with commercial stabilizers like Terrasil and Zycobond along with cement.
- We want to observe properties like MDD,OMC and CBR
- The amount of cement should be between 2% to 4% by soil mass.
- The amount of Terrasil and Zycobond should be 0.5%,1.0%,1.5% each by soil mass.

III. Methodology

The methodology adopted to achieve the required objectives is presented below. In the present work the methodology adopted is as follows:

- Characterization of materials
- Scheme of experiments
- Experimental procedure

3.1 Characterization of materials

The materials used in the present work are soft loose soil, zycobond and terrasil,cement.Characterization of these materials is as given in the following sections.

3.1.1 Characteristics of soft loose sandy Soil

Subgrade soil, soft loose sandy soil is used in the present work was collected from Lenora Engineering College, Rampachodavaram, East godavari district, Andhra pradesh. The index and engineering properties of the soil used in this work are presented as in Table 3.1.

Table 3.1.characteristics of soil

Property	Value
1.Specific gravity	2.59
2.Free swell index	10%
3.Co-efficient of gradation	2(uniform soil)
4.Co-efficient of curvature	1(single sized soil)
5.Maximum dry density	1.635 kg/m^3
6.Optimum moisture content	10.07 %

3.1.2.Characteristics of Zycobond (ZB)

Zycobond is a sub-micron acrylic copolymer emulsion with long life of above 10 years for bonding soil particles. It imparts water proofing and resists water ingress through the unpaved areas like shoulders and slopes. Characteristics of the chemical stabilizer used in this work are shown in Table 3.2. It is manufactured by ZYDEX INDUSTRIES. This leads to flexible bonding ,which improves the fatigue resistance of cement stabilization.

Table 3.2.Characteristics of zycobond

Parameter	value
1.Colour	Milky White
2.Odour	No
3.Flash point	above 100˚C
4.Explosion hazard	No
5.Ignition temperature	above 200 ˚C
6.Solubility in water	Dispersible
7.pH value	5-6

3.1.3.Characteristics of Terrasil (TS)

Terrasil is nanotechnology based 100% Organosilane, Water soluble, Ultraviolet and Heat stable, Reactive soil modifier to waterproof soil subgrade. It is available in concentrated liquid form and is to be mixed with water in specified proportion before mixing with the soil. Characteristics of the chemical stabilizer Terrasil used in this work is shown in Table.3.3. It is manufactured by ZYDEX INDUSTRIES.A photograph of it is shown in Fig.3.2.

Table 3.3. Characteristics of terrasil

Parameter	**Value**
Appearance	Pale yellow liquid
Solid content	68+2%
Viscosity at 25°C	20-100 cps
Specific gravity	1.01
Solubility	Forms water clear solution
Flash Point	Flammable 12 °C
Dosage	1% per m3

It restricts swelling to < 5% for expansive soils.It converts soil from hydrophilic to hydrophobic substance.

3.2 **Scheme of Experiments**

The detailed scheme of experiments, formulated to meet the objectives are presented in this section. In the first module it is intended to study the Compaction Characteristics of soil treated by varying % dosage of Zycobond and Terrasil.In The second module aim to understanding the CBR Characteristics of soft loose sandy soil treated with commercial stabilizer like terrasil and zycobond along with cement.

IV. Result Analysis

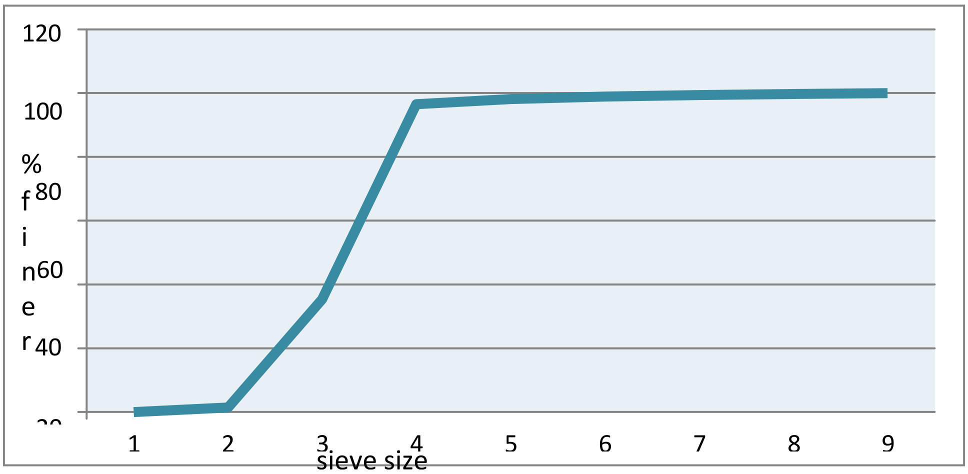
4.1 Specific gravity of soil (IS:2720 part-2)

Result : Specific gravity of soil = 2.59

4.2 Grain size analysis (IS:2720 part-4)

Table 4.1.grain size analysis

Sieve size(mm)	Mass of sieve(gm)	Mass of sieve &soil(gm)	Mass of soil retained(gm)	%of retained soil	Cummilative % retained	Percent finer(%)
4.75mm	436	436	0	0	0	100
2.00mm	360	361	1	0.2	0.2	99.8
1.00mm	390	392	2	0.4	0.4	99.4
600µ	380	382	2	0.4	1	99
425 µ	356	360	4	0.8	1.8	98.2
300 µ	344	352	8	1.6	3.4	96.6
150 µ	368	674	306	61.2	64.6	35.4
75 µ	352	522	179	34	98.6	1.4
pan	424	431	7	164	100	0



Graph 4.1sieve size vs % finer graph

Observations:

D_{10} = size at 10% finer by weight = 0.1mm D_{30} = size at 30% finer by weight = 0.2 mm D_{60} = size at 60% finer by weight = 0.14mm

Result:

C_u = <u>2 < 3(uniform soil)</u>

C_c = <u>1 (indicates a single sized soil)</u>

i.e..,The soil specimen is a single grained uniform soil.

4.3 **Free swell index IS:2720 part-40)**

Reference substance	Reading on test day(ml)	Reading on nxt day(ml)	Free swell index(%)
kerosene	10	10	0
Distilled water	10	11	10%

Table 4.2.Free swell index

Result

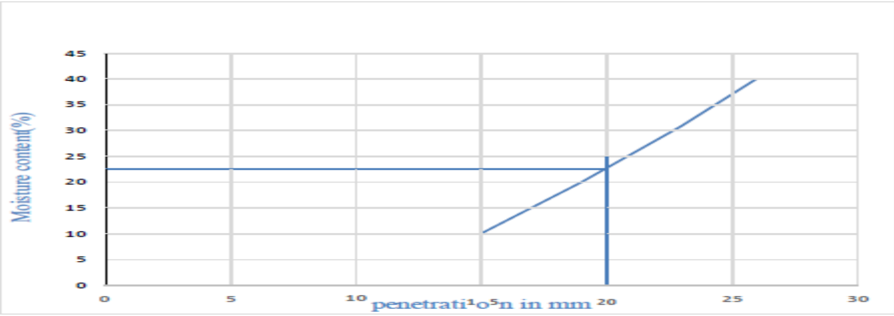
Free swell index=10%<50%

The soil is less swelling and suitable for subgrade**.**

4.4 Cone penetration test (IS:2720 part-5)

Table.4.3.cone penetration

Determination		Liquid limit			Plastic limit
	1	2	3	4	1
Penetration in mm	16	19	23	26	Non-plastic
Weight of container (W1) gm	37	32	37	31	Np
Wt. of container +wet soil(W2) gm	69.00	72.20	80.19	58.46	Np
Wt.of container + dry soil(W3) gm	60	66	70	51	Np
Weight of water (W2-W3) gm	9	6.20	10.19	7.46	Np
Weight of dry soil (W3-W1) gm	23	34	33	20	Np
Moisture content, [(W2-W3)/(W3-W1)]*100 (%)	39.13	18.23	30.87	37.3	Np



Graph 4.2.Penetration vs Moisture content

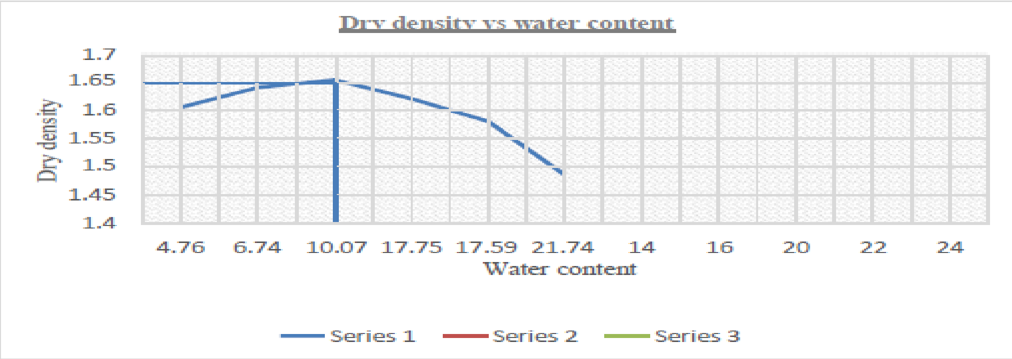
Result Liquid Limit = 21% and Plastic Limit = 0 (Non plastic)

4.4 Soil compaction (IS:2720 part-8)

Soil compaction for specimen

Test no.	1	2	3	4	5	6
Massof mould+compacted soil(gm)	7042	7117	7117	7272	7221	7170
Mass of compacted soil(wt gm)	1638	1713	1773	1868	1817	1766
Bulk density □ = Wt/V	1.681	1.75	1.82	1.91	1.86	1.81
Average water content(%)	4.76	6.74	10.07	17.75	17.59	21.74
Dry density, □d=□/(1+w)	1.604	1.639	1.653	1.62	1.58	1.486

Table 4.4.soil compaction



Graph 4.3.water content vs dry density

Result

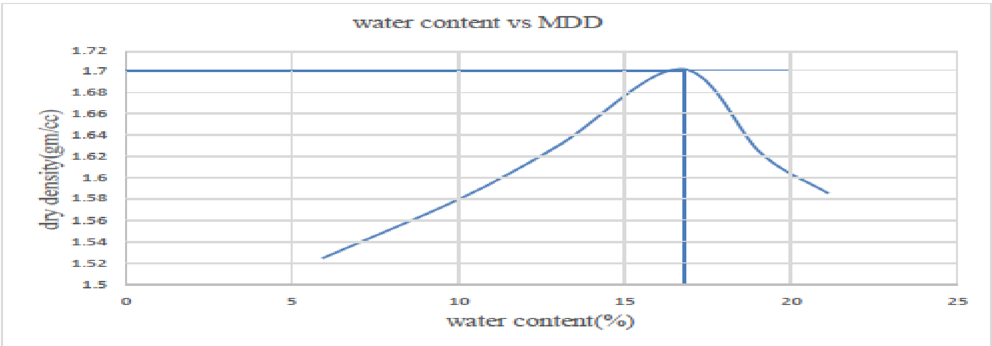
Maximum dry density (ρd) = 1.653 kg / m$^{3.}$

Optimum moisture content = 10.07%

4.5 Soil compaction with 2% cement

Table 4.5.Soil compaction with 2% cement

Test no	1	2	3	4	5	6
Mass of mould + compacted soi(gm)	6776	7098	7157	7339	7286	7278
Mass of compacted soil (gm)	1573	1695	1754	1936	1883	1875
Bulk density, □ = w/v	1.615	1.740	1.801	1.987	1.933	1.925
Average water content(%)	5.92	10.125	13.04	16.43	19.14	21.42
Dry desity □d = □ /(1+w)	1.524	1.581	1.593	1.702	1.622	1.585



Graph.4.4.soil compaction with 2% cement

Result

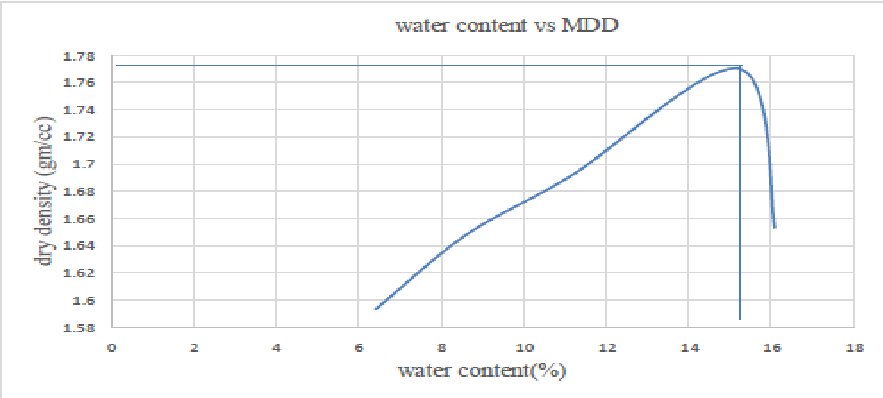
Maximum dry density = 1.702 gm/cc

Optimum moisture content = 16.73 %

4.6 Soil compaction with 4% cement and 0.5% Terassil and 0.5% Zycobond

Table.4.9.Soil compaction with 4% cement +0.5%Terassil+0.5%Zycobond

Test no	1	2	3	4	5	6
Mass of mould + compacted soil ,gm	7054	7155	7235	7392	7273	7260
Mass of compacted soil(gm)	1651	1752	1832	1989	1870	1857
Bulk density, □ = w/v	1.695	1.79	1.88	2.042	1.92	1.906
Avg water content,(%)	6.395	8.6	11.125	15.25	16.09	21.52
Dry density, □d = □ /(1+w)	1.593	1.648	1.691	1.77	1.653	1.568



Graph 4.6. Soil compaction with 4% cement +0.5%Terassil+0.5%Zycobond

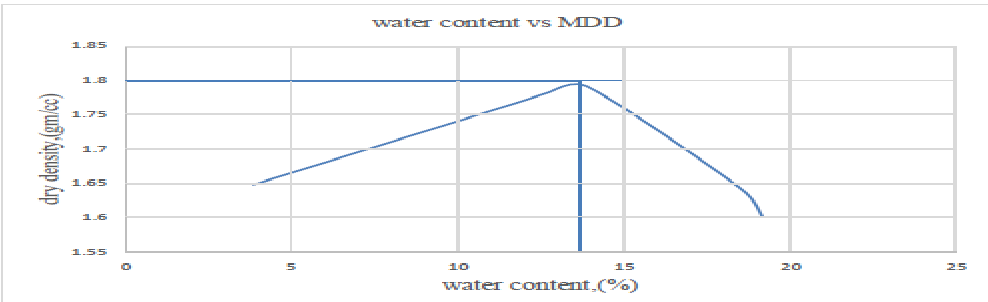
Result

Maximum dry density = 1.77 gm/cc Optimum moisture content = 15.25%

4.7 Soil compaction with 4% cement and 1.0% Terassil and 1.0% Zycobond

Table 4.10 . Soil compaction with 4% cement and 1.0% Terassil and 1.0% Zycobond

Test no	1	2	3	4	5	6
Mass of mould + compacted soil ,gm	7070	7157	7247	7389	7300	7205
Mass of compacted soil(gm)	1667	1748	1844	1986	1897	1802
Bulk density, = w/v	1.711	1.794	1.934	2.039	1.947	1.850
Avg water content,(%)	3.845	11.665	12.705	13.891	18.49	19.195
Dry density, = □ /(1+w)	1.647	1.764	1.715	1.790	1.643	1.552



Graph.4.7. Soil compaction with 4% cement and 1.0% Terassil and 1.0% Zycobond

Result Maximum dry density = 1.790 gm/cc

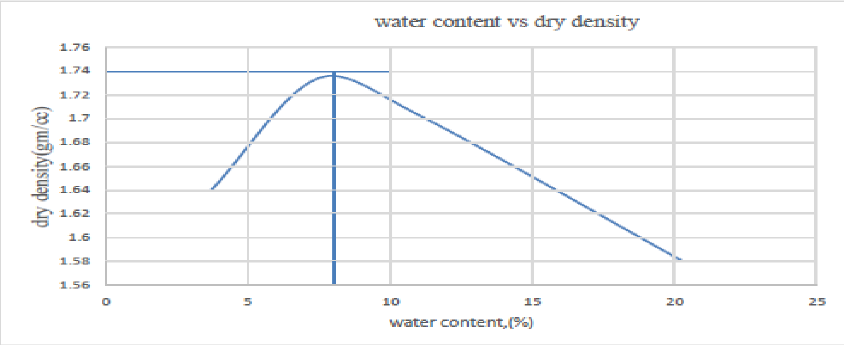
Optimum moisture content = 13.89%

4.8 **Soil compaction with 4% cement and 1.5% Terassil and 1.5% Zycobond**

Table 4.11. Soil compaction with 4% cement and 1.5% Terassil and 1.5% Zycobond

Test no	1	2	3	4	5	6
Mass of mould + compacted soil ,gm	7059	7220	7245	7317	7259	7253
Mass of compacted soil(gm)	1656	1817	1842	1914	1856	1850
Bulk density, = w/v	1.703	1.865	1.891	1.965	1.905	1.899

Avg water content,(%)	3.69	7.50	11.08	13.11	20.30	24.55
Dry density, = □ /(1+w)	1.639	1.734	1.702	1.736	1.58	1.524

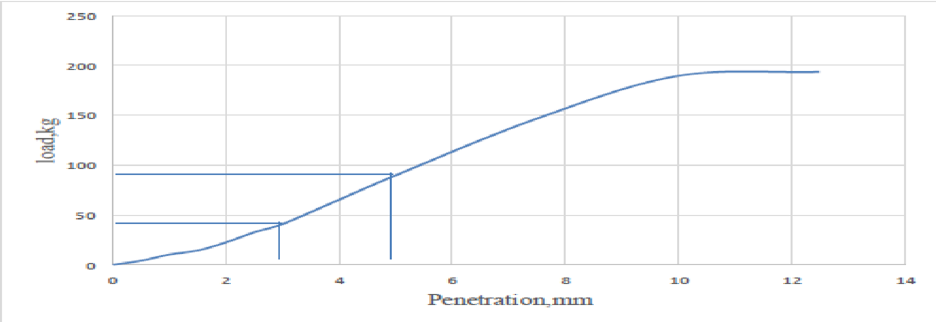


Graph 4.8. Soil compaction with 4% cement and 1.5% Terassil and 1.5% Zycobond

Result Maximum dry density = 1.736 gm/cc and Optimum moisture content = 13.11%

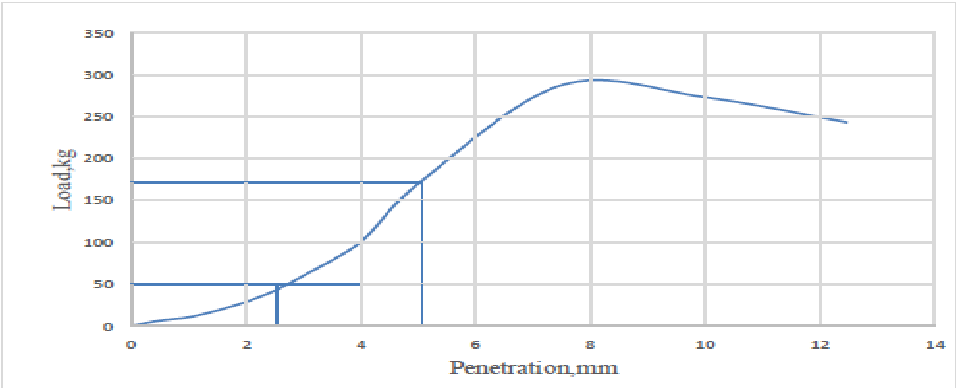
4.9 California Bearing Ratio test (IS:2720 Part -16)

4.9.1 CBR for normal soil



Result CBR at 2.5mm penetration = 2.38 and CBR at 5.0mm penetration = 4.36

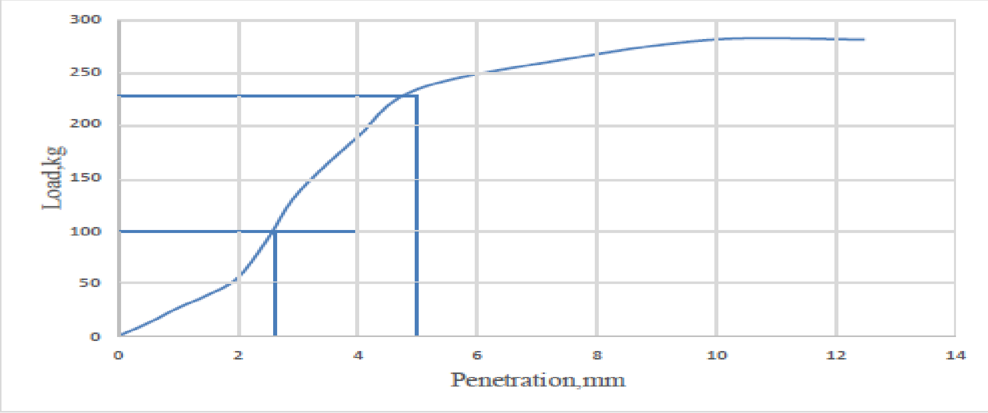
4.10 CBR for soil with 2% cement



Graph.4.10 CBR for soil with 2% cement

Result CBR at 2.5mm penetration = 3.4 and CBR at 5.0mm penetration = 8.2.

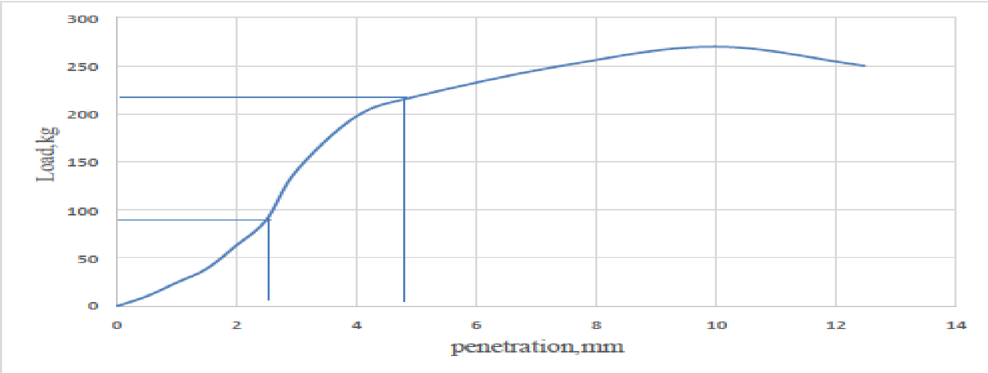
4.11 CBR for soil with 4% cement and 1.0% Terassil and 1.0%Zycobond



Graph.4.11.CBR for soil with 4% cement and 1.0% Terassil and 1.0%Zycobond

Result CBR at 2.5mm penetration = 6.69 and CBR at 5.0mm penetration = 11.30

4.12**CBR f**



or soil with 4% cement and 1.5% Terassil and 1.5%Zycobond

Graph.4.18.CBR for soil with 4% cement and 1.5% Terassil and 1.5%Zycobond

Result CBR at 2.5mm penetration = 6.54 and CBR at 5.0mm penetration =10.61

V. Conclusions

By observing the above result analysis the conclusion shown as follows:

- Initial dry density of normal sandy soil specimen is 1.65gm/cc.
- The dry density first increases and then decreased when soil is mixed with 4% cement and % increase of chemical as shown in graph.
- The maximum dry density is obtained at soil with 4% cement + 1.0% Terassil + 1.0%Zycobond
- The final dry density increased to 1.79 gm/cc..
- The OMC of sandy soil specimen is 12%
- The OMC of soil treated with 4% cement and %increase in chemical content will reduce OMC as shown in graph.
- The OMC increased to 13.11%.

References

[1]. Aparna Roy (2014), "Soil Stabilization using Rice Husk Ash and Cement",International Journal of Civil Engineering Research ISSN 2278-3652 Volume 5,Number 1 pp. 49-54.

[2]. Dallas N. Little, Syam Nair, (2009), "Recommended Practice for Stabilization of Subgrade Soils and Base Materials", National Cooperative Highway Research Program, Texas Transportation Institute, Texas.

[3]. Gundaliya P.J "Study of Black Cotton Soil Characteristics with Cement Waste Dust and Lime", Nirma University International Conference on Engineering (NUiCONE 2012) Procedia Engineering 51 (2013) 110 – 118.

[4]. James K. Mitchell and Sid Ahmed EL Jack,(1966) " Fabric Of Soil-Cement and Its Formation", Fourteenth National Conference On Clays And Clay Minerals, Vol.14; no. 1; p. 297-305

[5]. Keerthi Y, et al.(2013) "Stabilization of Clayey Soil using Cement Kiln Waste" International Journal of Advanced Structures and Geotechnical Engineering ISSN 2319- 5347, Vol. 02, No. 02 pp. 77-82

[6]. Lekha B.M, Ravi Shankar A.U, Goutham.S, (2013), "Laboratory Investigations of Soil Stabilized with Nano Chemical", Indian Geotechnical Conference pp.1-7

[7]. Lu Jiang, et al. (2004), "Stabilization Effects of Surplus Soft Clay with Cement and GBF Slag", Journal of Environmental Sciences Vol.16.No.3.pp.397-403

[8]. Norazlan Khalid et al.(2014) "The California Bearing Ratio (CBR) Value for Banting Soft Soil Subgrade Stabilized Using Lime-

Pofa Mixtures" Electronic Journal Of Geotechnical Engineering Vol. 19, 4247-4255

[9]. Odler, I., (1999). "Investigation on cement expansion associated with ettringite formation", Cement and Concrete Research, Vol,29, pp. 731735 [10] Sabat, A.K., Nanda, R.P. (2011). "Effect of marble dust on strength and durability of Rice husk ash

[10]. stabilized expansive soil." International Journal of Civil and Structural Engineering, Volume 1,No 4, pp.-939-948.

[11]. Sabyasachi Biswas, Arghadeep Biswas, Amar Dighade (2012), "Utilization of Rice husk with Lime in Subgrade Soil for a Rural Road." International Conference on Emerging Frontier in Technology for Rural Area, International Journal of Computer Application, EFITRA – No. 4 pp.1-3

[12]. Saravut Jaritngam et al. (2012) "An investigation of Lateritic Soil Cement for Sustainable Pavements" Indian Journal of Science and Technology Vol:5 Issue:11 ISSN:0974-6846 pp.3603-3606.

[13]. Supakij Nontananandh, Sanupong Boonyong, Thakon Yoobanpot (2012) "Investigations on Reaction Products In Soil Cement" National Convention on Civil Engineering No. 10, pp. 25472551

B.Veera Siva Prasad, " An Experimental Study On Soil Stabilization With Water Resistance " IOSR Journal of Computer Engineering (IOSR-JCE) 14.4 (2019): 32-41.