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A Study on The Effectiveness of Terrasil in Stabilizing Contaminated Soil

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Abstract— ***Contamination of soil is one of the major concern in the country like India. The rate of soil contamination has increased in past years due to the development activity. Soil is one of the natural construction material, which is used in excess. The properties of soil play a vital role in its strength and stiffness, used in the construction activities.***

Due to the improper soil waste management, the soil is being contaminated and are ineffective as construction material. There isa need of finding the replacement materials for the construction activities along with using the already existing materials by modifying its property to suit the requirements. The present study is focused on the assessment of terrasil as a stabilizer in the improvement of contaminated soil.

Laboratory tests were conducted to examine the strength properties of soil using standard compaction test and unconfined compression strength(UCS). The results for STP concluded that at 0.5% of terrasil a maximum dry density of 16.57kN/m^3 and Optimum moisture content of 18.65% was achieved and was found to be the optimum value to be used as effective soil stabilizer. The UCS test results concluded that terrasil at 1% achieved the maximum value of 732.56MPa, 1380.06MPa and 1389.0 MPa for 0th, 7th day and 21st day respectively. The CBR test results concluded that terrasil at 1% achieved the optimum value of 29.4% and 10.2% for unsoaked and soaked condition. The outcome of the research work highlights that 1% terrasil has achieved the optimum stabilizer for contaminated soil and hence, terrasil acts as a strong stabilizer by giving highstrength to soil, further providing the usage of contaminated soil for construction of subgrade in pavements.

Index Terms— ***Terrasil, Contaminated soil. UCS, Standard Compaction test***

I. INTRODUCTION

India is the seventh largest country with second highest population in the world. As there is an increase in population, the pollution rate drastically increases. This increase in pollution may be due to various reasons such as improper disposal of municipal solid waste on land, improper disposal of heavy and toxic metals or due to other environmental factors, etc. This leads to the contamination of soil which is referred as "Hazardous Soil".

Foundation engineering is one of the major part of any type of structure. the stability of structure mainly depends on the safe bearing capacity of soil. Due to the extensive disposal of waste the bearing capacity of soil gets reduces and effect the stability of structure. As the soil is contaminated consists of hazardous materials, it weakens the surface or subgrade and becomes difficult for engineers to start the construction of any structure on it. Mangalore creates around 250 tons of solid waste ordinarily out of which 200 tons is remedied and arranged into the landfill situated at vamanjoor a way of 15km from the city.

The primary waste created is from homes, markets from agribusiness items, retail and business markets, slaughter houses and ventures. This dump yard was begun in the mid 80's. the landfill yard has not exclusively been a source of air contamination yet in addition has sullied the ground water in the region. There are near 1250 families which leave roughly of 500m from dump yard. Leachate percolation has come about the groundwater turning dark and smelling foul in regions like mandara, jyothi nagar and Santhosh nagar which are in the region of vamanjoor [1]. In several technology constructions, soft and weak soils area unit usually stabilized with normal Portland cement (OPC) and lime. Therefore, it is necessary to know the properties of soil as it plays an important role in construction. In past scenario, stabilization of soil was conducted using lime, cement, bitumen etc. The assembly processes of ancient stabilizers area unit energy intensive and emit an outsized amount of greenhouse gas.

II. TERRASIL

The substance used for the current assessment to improve the contaminated soil was terrasil delivered by Zydex Industries, Gujarat, having fixings Hydroxyalkyl – alkoxy– alkysilyl mixes (65 – 70 %), Benzyl liquor (25 – 27 %) and Ethylene glycol (3 – 5 %). It is a nanotechnology based 100 percent organosilane, water dissolvable, splendid and warmth consistent, open soil modifier to waterproof soil subgrade. It reacts with water cherishing silanol social events of sand, soil, and sums to change over it to extraordinarily stable water repellent alkyl siloxane bonds and structures a breathable in-situ layer. The holding procedure starts inside of 3 hours of the beginning application and the procedure is finished (72 hrs.), terrasil turns into a lasting piece of every soil particle and won't separate or drain into groundwater [2].

III. LITERATURE REVIEW

Following are some of the researches carried in the field of soil stabilization of contaminated soil:

Ya-nan et.al., [3] The role of biogenic manganese oxide (BMO) materials on the stabilization of arsenic (As) in contaminated soil was investigated. Experimental results indicated that the addition of BMO proved to be highly effective to stabilize as in soils. Soluble content of as decreased 49.5-67.4% with a dosage of 0.013-0.063% BMO. X-ray absorption near edge structure results confirmed that BMO is mainly responsible for oxidizing as(III) to as(V) through a two-step pathway.

Mingming et.al., [4] A biochar was used as a stabilizat**4**i**.**on agent to remediate Cu- and Pb-contaminated sediments, collected from three locations in or close to Beijing. The sediments were mixed with a palm sawdust gasified biochar at a range of weight ratios (2.5%, 5%, and 10%) and incubated for 10, 30, or 60 days. The results showed that biochar could enhance the stability of heavy metals in contaminated sediments.

Mane et.al., [5] In the present study, it is to evaluate the effectiveness stabilizers viz., Zycobond, Terrasil.. For the clay used in this study there was a increase of 57.21% in the CBR value for unsoaked condition when it is stabilized with Terrasil and Zycobond, there was a drop of 19.62 % in the CBR value when it was soaked for four days.

IV. METHODOLOGY

The contaminated soil was collected from the dump yard at 4 different points which is located near Mangalore. A laboratory testing includes specific gravity [6], moisture content [6], particle size distribution [7], liquid limit [8], plastic limit [8], shrinkage limit [9], permeability test [10], standard proctor test [11], unconfined compressive strength (UCS) [12] and California bearing ratio (CBR) [13] for natural soil (NS) and contaminated soil (CS). Depending upon the test results, out of 4 contaminated soil samples lowest sample is considered for further process. The standard proctor test and unconfined compressive strength was carried out for contaminated soil with varying percentage of terrasil of about 0%, 0.5%, 1% and 1.5%.

Fig. 1 Vamanjoor Dump yard site

Fig. 2 Soil Samples collected from Vamanjoor Dump yard site

Figs. 3 and 4 Standard Proctor test for contaminated soil

Fig. 5 Preparation of UCS samples for contaminated soil

Fig. 6 UCS prepared samples undercuring

Fig. 7 Unconfined Compression Testing

V. RESULTS AND DISCUSSIONS

Specific gravity and water content tests were carried outfor natural soil (NS) and contaminated soil samples (CS). Table 1 indicates the results that are obtained.

Table 1. Test results of Specific gravity and natural water content

Type	Specific gravity	Natural Water content (%)
NS	2.53	33.82
CS -1	2.15	20.82
CS -2	2.14	17.17
CS -3	2.58	16.35
CS -4	2.53	12.40

Note:
NS- Natural soil
CS 1,2,3,4 – Contaminated soil samples

According to IS, soil classification system was carried out for both NS and CS, fig 7 shows the clear graph obtained.

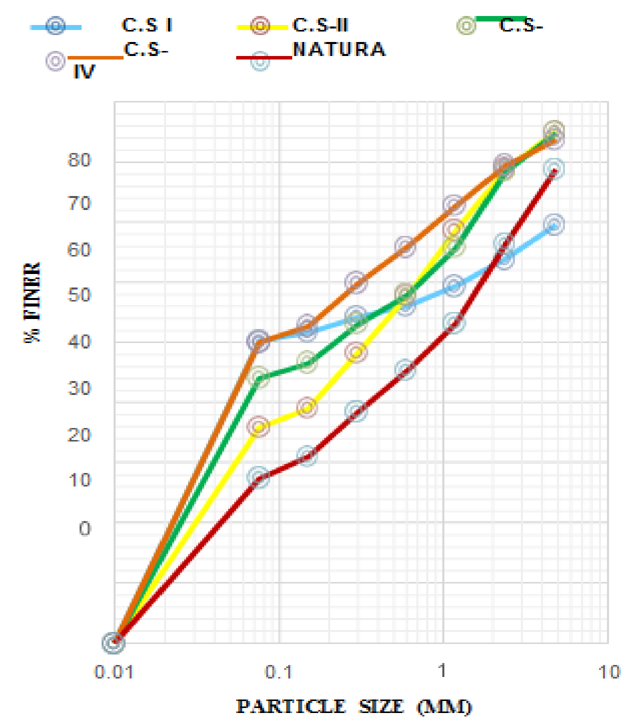

Fig. 8 Graphical representation of particle size distribution

Table 2. Particle size and Soil Classification

Type	Gravel	Sand	Fines	IS Classification
NS	21.28	21.44	57.28	SC
C.S-I	30.56	19.28	50.16	MI
C.S-II	14.96	49.28	35.76	SM
C.S-III	15.12	40.8	44.08	SC
C.S-IV	15.4	33.6	51.0	CI

The tests suchas atterberg's limit for NS and CS samples were performed as per IS standard codes. Table 3 represents

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the results.

Table 3. Atterberg's limit test results

Type	Liquid limit (%)	Plastic limit (%)	Shrinkage limit (%)
NS	31	20.38	35.76
CS -1	52	34.21	30.64
CS -2	NP	NP	NP
CS -3	39.29	26.07	32.41
CS -4	36.1	20.06	33.86

Table 4. Permeability Test Results

(cm/s)	CONSTANT HEAD AVERAGE	VARIABLE HEAD AVERAGE
NS	$K = 5.803*10^{-4}$	K = 3.050*10-4
CS -1	$K = 3.818*10^{-4}$	$K = 1.595*10^{-4}$
CS -2	$K = 2.197*10^{-3}$	$K = 6.653*10^{-4}$
CS -3	$K = 1.764*10^{-3}$	$K = 4.583*10^{-4}$
CS -4	$K = 1.279*10^{-3}$	$K = 4.016*10^{-4}$

Permeability test was carried out for all the soil samples as per IS codes and table 4 shows the values obtained.

The standard proctor test was carried out for NS and CS samples according to IS standard procedure. Fig 8 shows the variation of soil samples were. Table 5 represents the MDD and OMC for all thesoil samples.

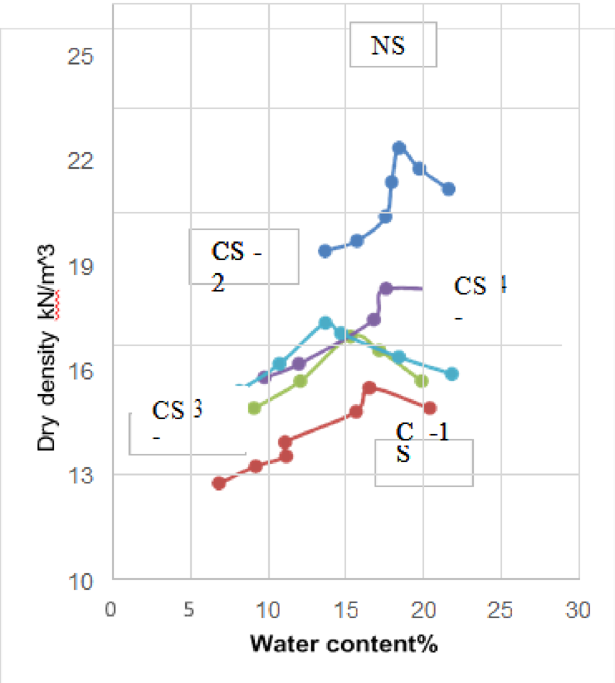

Fig. 9 Graph obtained for standard proctor test of different types of soil samples

Table 5. Values obtained for compaction test results

Type	OMC %	MDD kN/m^3
NS	18.6	22.36
CS -1	16.63	15.49
CS -2	13.79	17.36
CS -3	15.41	16.97
CS -4	17.71	18.34

Unconfined Compressive strength was performed on NS and CS samples. Fig 9 shows the variation of strength for different types of soil and Fig 6 represents the UCS samples prepared and projected under loading.

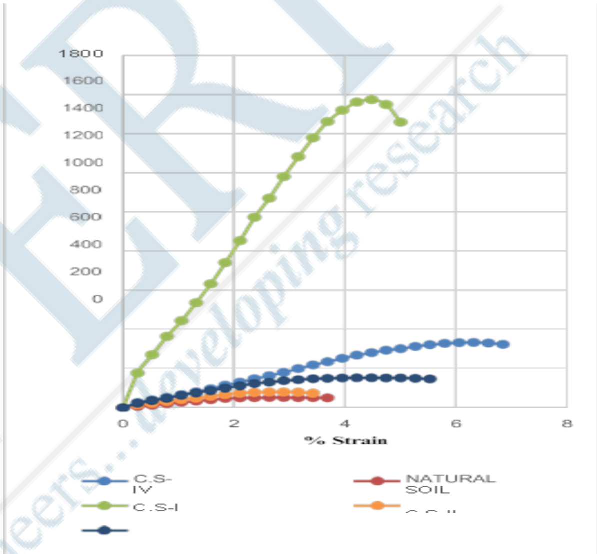

Fig. 10 Graph obtained for UCS of different types of soil samples

VI. TERRASIL AS A STABILIZER

Considering the soil sample, C1 the standard proctor tests and unconfined compressive strength were performed using the stabilizer.

The standard proctor test was carried out for CS samples with terrasil stabilizer according to IS standard procedure. Fig 10 shows the terrasil added to the contaminated soil samples.

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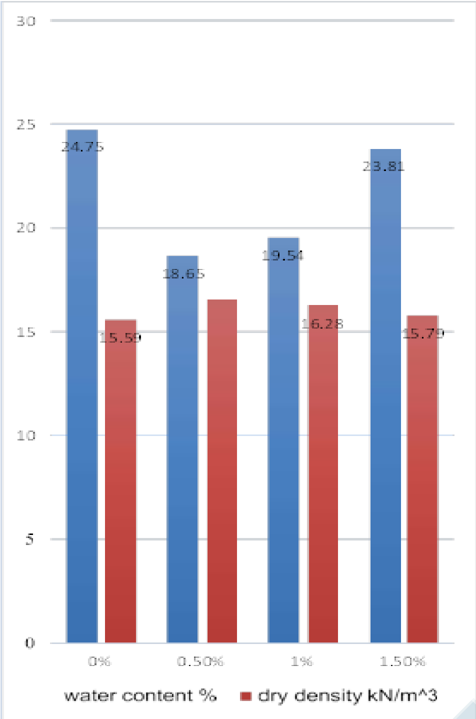

Fig. 11 Graph obtained for standard proctor test for different stabilizer range of soil sample

From the above graph, it clearly shows that 0.5% has achieved MDD of about 16.57kN/m^3 and OMC as 18.65%.

The unconfined compressive strength was carried out for CS samples with terrasil stabilizer by considering OMC from standard proctor tests for the percentages mentioned above

The test results were analyzed in 3 different conditions: -

1) Samples were prepared and tested on the 0^{th} day for 0%, 0.5%, 1% and 1.5%.
2) Samples were prepared and tested on the 7^{th} day for 0.5%, 1% and 1.5%.
3) Samples were prepared and tested on 21^{st} day for 0.5%, 1%, and 1.5%.

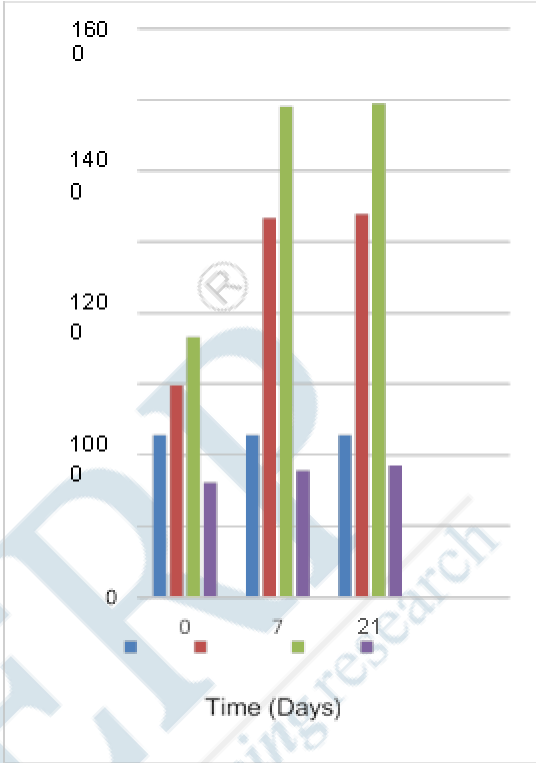

Fig. 21 UCS values obtained for variation of stabilizer with respect to days

Table 6. UCS results

Days/ Dosage	0%	0.5%	1%	1.5%
	MPa			
0	456.8	594.65	732.56	322.78
7	456.8	1067.97	1380.06	355.71
21	456.8	1078.66	1389.0	369.29

From the above table 6, it is observed that 1% of terrasil has achieved an optimum value of compressive strength of 732.53MPa, 1380.06MPa and 1389.0MPa for 0th, 7th and 21st day respectively.

The California bearing ratio test was carried out for CS sample with terrasil stabilizer by considering optimum percentage of stabilizer from unconfined compressive strength.

Table 7. CBR results

Optimum stabilizer (1%)	Un-Soaked condition (%)	Soaked condition (%)
Natural soil (NS)	27.4	7.4
CS- Without stabilizer	21.2	5.1
CS-With stabilizer	29.4	10.2

From the table 7 it shows that, the California bearing ratio results are 29.4% and 10.2% for unsoaked and soaked conditions for contaminated soil of terrasil at 1%.

VII. CONCLUSIONS

Various experiments on the contaminated soil were carried out to study and understand the geotechnical properties of it. The differences between the contaminated soil as well as a normal healthy soil were analyzed through the experimental results. The investigation was to estimate the effectiveness of terrasil as stabilizer on contaminated soil. From the results obtained by various experiments it is concluded that by using terrasil stabilizer on contaminated soil. The unconfined compressive strength and CBR values were found higher than natural soil. The effectiveness of terrasil stabilizer for contaminated soil samples has been proven that 0.5% and 1% has achieved the optimum for standard proctor test and unconfined compressive strength for (0th ,7th and 21st day). The CBR test was conducted for contaminated soil at 1%, results achieved through this experiment are 29.4% and 10.2% for unsoaked and soaked conditions. Hence, CBR values are within the standard limits and it can be used as a subgrade for pavements. The effect of terrasil was carried out on standard proctor test, unconfined compressive strength and California bearing ratio test which showed the positivity of stabilizer than the expected. In case of durability, as the day's increase, effect of stabilizer with respect to compressive strength also increases. Thus it can be concluded that Terrasil can be used in soil stabilization of weal contaminated soils and these soils can be used in various contaminated activities.

REFERENCES

[1] Donal Nixon D'Souza, P.S. Aditya, S. SavithaSagari, Deepanshi Jain and Dr.N.Balasubramanya, "Study of groundwater contamination due to a dump yard: A Case Study of Vamanjoor Dump Yard, Mangalore", Proceedings of International Conference on Advance in Architecture and Civil Engineering Vol 1, June 2012.

[2] Lekha B. M, GouthamSarang, Chaitali N Ravi Shankar, "A laboratory investigation on black cotton soil stabilized with nontraditional stabilizer", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p- ISSN: 2320- 334X PP 07-13 (2011).

[3] Ya-nan Wang, Yi Song, Huawei Wang, Yingjie Sun, Yiu Fai Tsang, Xiangliang Pan, "Effective stabilization of arsenic in contaminated soils with biogenic manganese oxide (BMO) materials", Environmental Pollution, October (2019).

[4] Mingming Wang, Liangsuo Ren, Dayang Wang, Cai Zuansi, Xuefeng Xia, Aizhong Ding, "Assessing the capacity of biochar to stabilize copper and lead in contaminated sediments using chemical and extraction methods", Journal of Environmental Sciences, Volume 79, May (2019).

[5] Mane S R Rohitha, Dr.R.Srinivasa Kumar, William Paul, Nagilla KumaraSwamy "A study on the effect of stabilizers (zycobond & terrasil) on strength of subgrade on BC soil", Indian J.Sci.Res. 17(2): 86-92, (2018).

[6] IS 2720-3 (1964), "Bureau of Indian Standards Manak Bhavan", 9 Bahadur Shah Zafar Marg New Delhi 110002.

[7] IS 2720-4 (1985), "Bureau of Indian Standards Manak Bhavan", 9 Bahadur Shah Zafar Marg New Delhi 110002.

[8] IS 2720-5 (1985), "Bureau of Indian Standards Manak Bhavan", 9 Bahadur Shah Zafar Marg New Delhi 110002.

[9] IS 2720-6 (1972), "Bureau of Indian Standards Manak Bhavan", 9 Bahadur Shah Zafar Marg New Delhi 110002.

[10] IS 2720-17 (1986), "Bureau of Indian Standards Manak Bhavan", 9 Bahadur Shah Zafar Marg New Delhi 110002.

[11] IS 2720-7 (1980), "Bureau of Indian Standards Manak Bhavan", 9 Bahadur Shah Zafar Marg New Delhi 110002.

[12] IS 2720-10 (1973), "Bureau of Indian Standards Manak Bhavan", 9 Bahadur Shah Zafar Marg New Delhi 110002.

[13] IS 2720-31 (1990), "Bureau of Indian Standards Manak Bhavan", 9 Bahadur Shah Zafar Marg New Delhi 110002