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EXPERIMENTAL STUDY ON STABILIZATION OF BLACK COTTON SOIL USING TEXTILE SLUDGE WASTE TREATED WITH HYDRATED LIME

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ABSTRACT

Construction industry is very crucial for infrastructure improvement because it gives enormous rise to country's economy. Since black cotton soil are very fertile soil, so they are not good for pavement and foundation [1]. Black cotton soil is expansive clay, since it processes high swelling and shrinkage characteristics due to change in moisture content. Soil enhancement skill like stabilization and reinforcement are hired to improve geotechnical properties of soil, thereby strengthening the reliability of construction. Textile sludge waste was added to black cotton soil in varying proportions of 10 %, 20 %, 30 %, 40 % and 50 %. Hydrated lime was added to soil in varying proportions of 2 %, 4 %, 6 %, 8 % and 10 % with the optimum proportions obtained from textile sludge waste. The outcome drawn from this debate is that black cotton soil stabilized with textile sludge waste and hydrated lime showed optimum performance in prescription of 20 % and 6 % correspondingly by weight of soil.

Index terms - black cotton soil, stabilization, textile sludge waste, hydrated lime, atterberg's limit, standard proctor, UCC & CBR.

INTRODUCTION

Black cotton soil is found in extensive region of Deccan Trap in India. They are of variable thickness, underlay by black sticky material known as "black soil or regur soil". Black soil is considered as a very poor type of soil having black colour with very fine grain. Because of its large bump and contraction characteristics, the black cotton soil has been a test to the civil and highway engineers. Black cotton soil is represented as medium to high compressibility and plasticity, high shrinkage and swelling properties [Hema and Suneel, 2009]. The meteorology of the soil is over showed by the presence of montmorillonite which is ident-ify by a enormous amount of change from misty to dry seasons and vice versa.

The dyeing industry exhausts huge volumes of water and solid waste, which produces voluminous quantities of waste from different stride in the dyeing and washing processes. Waste from printing and dyeing units is usually enriched in colour, containing residues of reactive dyes and chemicals which require proper treatment before being clemency into the environment [Mary and Sreeja, 2014]. The lethal outcome of pigments and other organic compounds, as well as sour and alkali toxins from industrial production on the public are widely accepted. ETP sludge disposal is being one of the major and oldest sectors in India are also battling with the problem of Textile industry. To precaution the environment, resolutions are being made for reusing different wastes and to exploit them in value added appliances. Many researches are going on to find a solution for the industrial solid waste. Sludge is dried in sludge drying beds and sent for land filling because of its chemical nature.

Hydrated lime (calcium hydroxide) is a dry, colourless translucent powder mass-produced by regulating calcium oxide (quicklime) with water, in a process called "slaking". It is also known as slack lime, which is used in the construction of mortars, plasters [Mitchell, 1986], stiff rubber products and chiefly in the tanning of leather. Use of lime well changes the characteristics of a soil to outcome long-term perpetual strength and stability, especially with respect to the action of water and frost [Norazlan, Mazidah, 2012].

Therefore, stabilization is the process, where supplements are mixed with waste to reduce the rate of pollutant migration and to pare the toxicity of waste. In this study, industrial waste such as textile sludge waste was added to black cotton soil in various proportions of 10%, 20%, 30%, 40% and 50% respectively. And in addition to that, hydrated lime was added to soil in varying proportions of 2%, 4%, 6%, 8% and 10% with the optimum proportions obtained from textile sludge waste.

Based on the test results the soil sample is classified as clay of high compressibility (CH) as per BIS 1498 – 1970. Geotechnical properties such as Differential free swell, Atterberg's limit, Standard proctor compaction test, Unconfined Compressive Strength test and California Bearing Ratio test are to be determined.

OBJECTIVE OF THE STUDY

To determine the strength characteristics of black cotton soil with addition of industrial waste such as textile sludge in varying proportions of 10%, 20%, 30%, 40% and 50% respectively.

To evaluate the strength characteristics of black cot-ton soil treated with hydrated lime in varying proportions of 2%, 4%, 6%, 8% and 10% with the optimum proportion obtained from textile sludge waste for 7 days curing periods.

MATERIALS

In this project with the black cotton soil, indus-trial wastes and hydrated lime are used for the investigation. The industrial waste such as textile sludge waste is used as stabilizing material for the clayey soil.

a. SOIL SAMPLE: The clay used in this study is collected from Red Hills which is having latitude 13˚11'57" N and longitude 80˚11'48" E. The sam-ple is collected at a depth of 1.5 to 3 m from the ground surface.

b. **TEXTILE SLUDGE WASTE**: Textile sludge waste was collected from the printing industry, located in Erode. Textile sludge waste has some pozzolanic materials, so the sludge waste has been used in the manufacture of cement. The chemical compo-sition for textile sludge waste was obtained from MIT, Chennai.

Table I: Chemical composition of textile sludge waste

Chemical Composition	Weight %	Atomic %
C	15.37	22.75
O	59.37	66.00
Mg	0.55	0.40
Ca	24.11	10.71
As	0.57	0.14

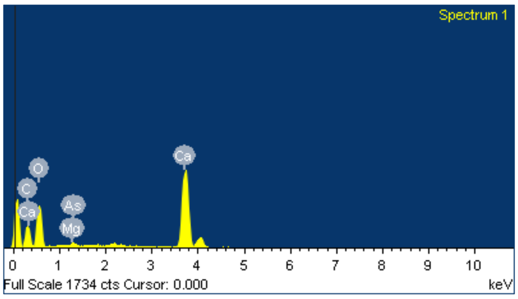

Fig 1: EDAX graph for textile sludge waste

c. HYDRATED LIME: Hydrated lime is collected from Erode. The chemical composition for hydra-ted lime was obtained from MIT, Chennai.

Table II: Chemical composition of hydrated lime

Chemical Composition	Weight %	Atomic %
O	8.00	17.89
Ca	92.00	82.11

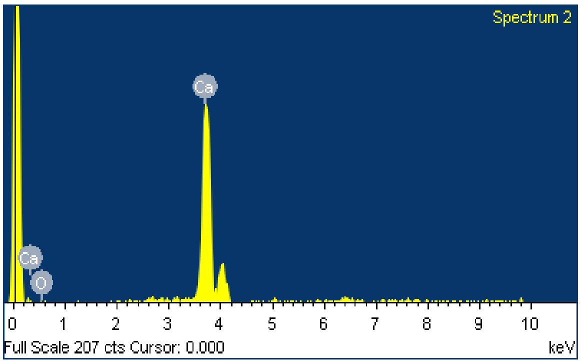

Fig 2: EDAX graph for hydrated lime

METHODOLOGY

The various laboratory tests were conducted on untreated soil and treated soil with industrial waste materials as per IS standard to determine the index and engineering properties of soil. The soil samples treated with textile sludge waste in varying proportions of 10%, 20%, 30%, 40% and 50 % respectively. The soil treated with hydrated lime in varying proportions of 2%, 4%, 6%, 8% and 10% with the optimum proportion obtained from textile sludge waste for different curing periods [Shrikant & Shrihari, 2012]. The soil treated with industrial waste materials determines the unconfi-ned compressive strength and California bearing ratio for 7 days curing period.

EXPERIMENITAL INVESTIGATION

Table III: Engineering properties of virgin soil sample

S. No	Properties	Results for virgin soil sample
1	Differential free swell index	90 %
2	Specific gravity	2.72
3	Liquid Limit (W_L)	66 %
4	Plastic Limit (W_P)	24.48 %
5	Plastic Index (I_P)	41.52 %
6	Shrinkage Limit (W_S)	10.20 %
7	Soil classification	CH
8	Optimum moisture content	17.5 %
9	Maximum dry density	1.57 g/cc
10	Unconfined compressive strength	0.208 N/mm^2
11	Cohesion	0.104 N/mm^2
12	California bearing ratio	7.28 %

RESULTS AND DISCUSSION

a. The unconfined compressive strength is obtained by conducting unconfined compressive strength test. The test is conducted as per IS: 2720 – 1991 (part X).

The variation of OMC and MDD for varying per-centage of textile sludge waste is shown in Fig 3.

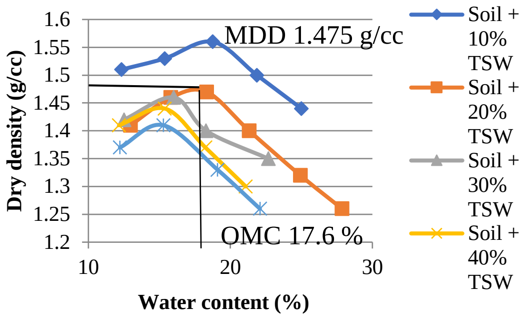

Fig 3: Variation of OMC and MDD

The variation in Shear strength for varying percentage of textile sludge waste for without curing is shown in Fig 4.

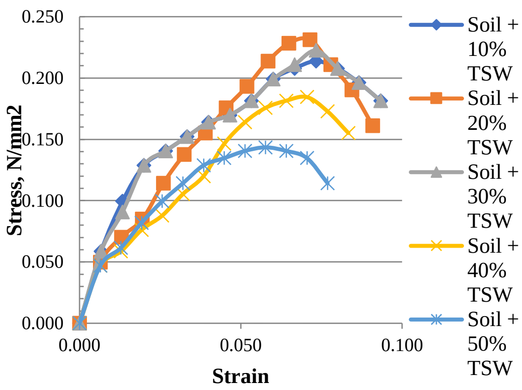

Fig 4: UCC graph for varying percentage of textile sludge waste (without curing)

The variation in Shear strength for varying percentage of textile sludge waste for 7 days curing is shown in Fig 5.

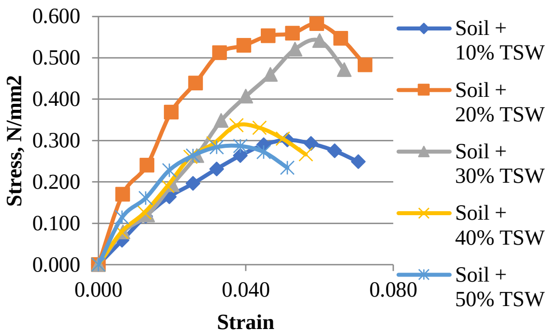

Fig 5: UCC graph for varying percentage of textile sludge waste (7 days curing)

Table IV: Variation in shear strength for textile sludge waste

Sl. No	Description	Without curing	7 days curing
1	Soil + 0% TSW	0.208	0.275
2	Soil + 10% TSW	0.214	0.302
3	Soil + 20% TSW	0.231	0.583
4	Soil + 30% TSW	0.222	0.542
5	Soil + 40% TSW	0.184	0.337
6	Soil + 50% TSW	0.143	0.287

The variation in shear strength for 20 % textile sludge waste with varying percentage of hydrated lime for 7 days curing is shown in Fig 6.

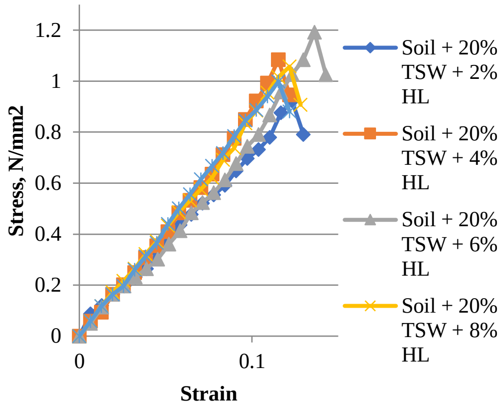

Fig 6: UCC graph for varying percentage of hydrated lime (7 days curing)

Table V: Variation in shear strength for hydrated lime

Sl. No	Description	7 days curing
1	Soil + 20% TSW + 0% HL	0.583
2	Soil + 20% TSW + 2% HL	0.922
3	Soil + 20% TSW + 4% HL	1.083
4	Soil + 20% TSW + 6% HL	1.192
5	Soil + 20% TSW + 8% HL	1.057
6	Soil + 20% TSW + 10% HL	0.998

b. The California bearing ratio (CBR) test is conducted as per IS: 2720 (part XIV).

The variation in CBR strength for varying percentage of textile sludge waste for without curing is shown in Fig 7.

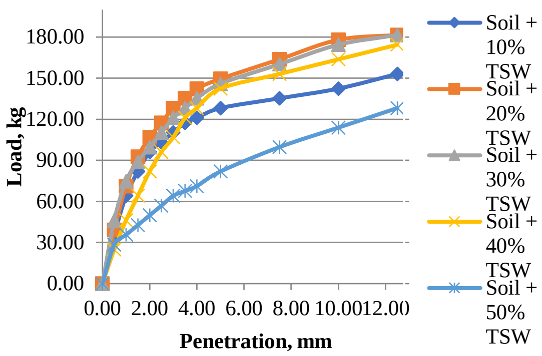

Fig 7: CBR graph for varying percentage of textile sludge waste (without curing)

The variation in CBR strength for varying percentage of textile sludge waste for 7 days curing is shown in Fig 8.

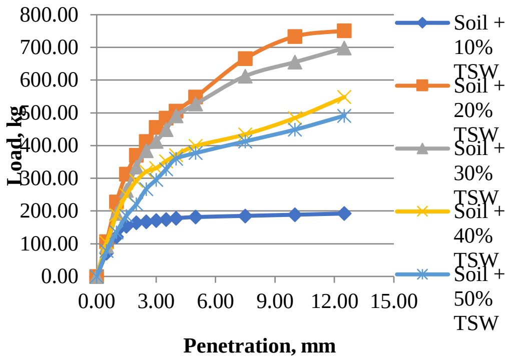

Fig 8: CBR graph for varying percentage of textile sludge waste (7 days curing)

Table VI: Variation in CBR for textile sludge waste

Sl. No	Description	Without curing	7 days curing
1	Soil + 10 % TSW	7.54	12.21
2	Soil + 20 % TSW	8.58	30.14
3	Soil + 30 % TSW	8.06	28.06
4	Soil + 40 % TSW	7.02	23.39
5	Soil + 50 % TSW	4.16	19.49

The variation in CBR for 20% textile sludge waste with varying percentage of hydrated lime for 7 days curing is shown in Fig 9.

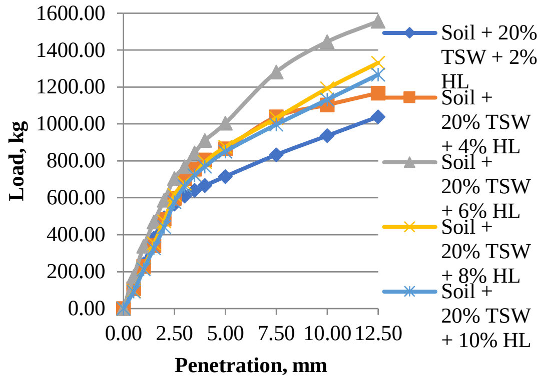

Fig 9: CBR graph for varying percentage of hydrated lime (7 days curing)

Table VII: Variation in CBR for hydrated lime

Sl. No	Description	7 days curing
1	Soil + 20% TSW + 0% HL	30.14
2	Soil + 20% TSW + 2% HL	41.32
3	Soil + 20% TSW + 4% HL	43.66
4	Soil + 20% TSW + 6% HL	51.45
5	Soil + 20% TSW + 8% HL	44.95
6	Soil + 20% TSW + 10% HL	42.10

CONCLUSION

Based on the experimental analysis on stabilization of soil, the following results are drawn.

1. The liquid limit (LL) of untreated soil was 66%. It has increased to 18.94% at 20% textile sludge waste. On further addition of textile sludge waste, LL has finally decreased to 7.58%.
2. The plasticity index (PI) of untreated soil was 41.52%. It has decreased to 24.28% at 20% textile sludge waste. On further addition of textile sludge waste, PI has finally reduced to 76.61%.
3. The shrinkage limit (SL) of untreated soil was 10.20%. It has increased to 39.12% at 20% textile sludge waste. On further addition of textile sludge waste, SL has finally increased to 189.02%.
4. The unconfined compressive strength of untreated soil was 208 kN/m^2. The addition of textile sludge waste has increased the UCC strength from 208 kN/m^2 to 231 kN/m^2 at 20 % textile sludge waste. The percentage increase in textile sludge waste is 11.06 %.
5. The unconfined compressive strength of soil with 20% textile sludge waste and 0.6% hydra-

ted lime has increased from 583 kN/m^2 to 1192 kN/m^2. The percentage increase is 104.46 %.

6. California bearing ratio of untreated soil was 7.28%. The addition of textile sludge waste has increased the CBR strength from 7.28% to 8.58% at 20% textile sludge waste. The percentage increase in textile sludge waste is 17.86 %.
7. California bearing ratio of soil with 20% textile sludge waste and 0.6% hydrated lime has increased from 30.14% to 51.45%. The percentage increase is 70.70 %.

REFERENCES

Brajesh Mishra, A Study on Engineering Behavior of Black Cotton Soil and its Stabilization by Use of Lime. International Journal of Science and Research (2013).

Hema Patel & Suneel Pandey, Exploring the Reuse Potential of Chemical Sludge from Textile Wastewater Treatment Plants in India-A Hazardous Waste. American Journal of Environmental Sciences 5 (1): 106-110 (2009).

Mary Lissy P.N. & M.S. Sreeja, Utilization of sludge in manufacturing Energy Efficient Bricks. Journal of Mechanical and Civil Engineering (IOSR-JMCE) 11(4): 70-73 (2014).

Mitchell, J. K., Practical problems from surprising soil behavior. Journal of Geotechnical Engineering 112(3): 259–289 (1986).

Norazlan Khalid & Mazidah Mukri, Clay soil stabilization using waste paper sludge ash (WPSA) mixtures, Vol. 17 , Bund. I (2012).

Padmini J., B.Priyanka & M. Swapna, Effect of lime stabilization flyash layer on CBR values of black cotton soil, IGC Ahmedabad, INDIA (2005).

Pappu A., M. Saxena & S.R. Asolekar. Solid waste generation in India and their recycling potential in building material. Journal of Building and Environment 42: 2311-2320 (2007).

Ravikrishnan, S. & S. SenthilSelvan, Novel Green Bricks manufactured from Textile ETP Sludge. International Journal of Scientific & Engineering Research 5(6): (2014).

Sharma, A.K. & Sivapullaiah, P.V., Ground granulated blast furnace slag amended fly ash as an expansive soil stabilizer. Soils and Foundations. 56(2): 205-212 (2016).

Shrikant S Jahagirdar & S. Shrihari, Reuse of textile mill sludge in cement based solid blocks. International J. of Engg. Research & Indu. Appls. 5 (III): 213-224 (2012).

Shrikant S. Jahagirdar, S. Shrihari & B. Manu, Utilization of Textile Mill Sludge in Burnt Clay Bricks. International Journal of Environmental Protection 3(5): 6-13 (2013).

Vinothkumar R. & P.D. Arumairaj, Green Stabilization of Coimbatore Clay. International Journal of Engineering and Innovative Technology 2(11): (2013)