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Effect of Silk Dyeing Alkali Effluent on the Compaction and Strength behaviour of Expansive Black Cotton Soil

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Abstract : *Rapid industrialization and urbanization in India leads to development of industries resulting in discharge of by-products, effluent wastes being a great challenge to Civil Engineering community. Due to intrusions of alkaline effluent into the soil has change the compaction and strength behaviour of soil effluent matrix. In this paper silk dyeing effluent has been mixed with expansive soil and compaction and strength tests has been conducted as per IS guidelines. From the test results, it has been found that addition of alkaline effluent in soil has reduced the Maximum Dry Density to about 3.5%. The Unconfined Compressive Strength tests conducted to their Optimum Moisture Content and Maximum Dry Density. These tests were continued for varying curing periods. Soil treated with 30% alkaline effluent has shown 2 folds increase in the strength compared to other combinations.*

Keywords– *Folds, Matrix, Maximum Dry Density.*

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I. Introduction

In India, soils were broadly classified into five types. Each type of soil will impose its own challenge to the geotechnical engineers, in terms of complexity. Expansive soil plays a vital role in this context. On the other hand due to industrialization and urbanization the disposal of effluent/wastes/by-products into the ground/inside the mother earth has triggers the infinite challenges at nanotechnology level to the geotechnical engineers. In the recent days, because of industrialization comfort zone of a human being has increased, this leads to the huge development of cloth industries like silk dyeing industries, establishment of textile mills. These industries using poisonous dyes for colouring fabrics in cloths. These colours coated on the fabric has to be rinsed before woving. These rinsed water contains both acidic and alkaline effluent which is directly discharged into the open drains in Vijayapur zone, Bengaluru, Karnataka state, India which will not only pollute ground water table but also alters the geotechnical properties of the soils.

II. Review Of Literature

Several researchers done an attempt to study the behaviour of discharged effluent on geotechnical properties of soil. Ayininuola and Agbede (2014) says that soil contaminated with sodium chloride increases the permeability, whereas soil contaminated with calcium sulphate reduced the permeability[1]. Transformation of minerals present in black cotton soil on reaction with NaOH studied by Sivapullaiah et al., (2010). They found that higher the concentration of alkali, the higher is the increase in moisture adsorption with humidity [2]. Rao and Indiramma (2009) have reported in their investigation that textile effluent is found to be effective in reducing liquid limit as well as swelling properties, increasing strength and compaction characteristics and stability of soil mass increased due to increase in the textile effluent concentration[3]. Influence of textile dye waste on clayey soil was studied by Mallikarjuna et al., (2008) and found that, pH promotes a positive edge to negative surface interaction leading to flocculated structure[4]. However, very few researches are highlighted about compaction and strength behaviour of soil treated with alkaline effluent in their isolated conditions.

III. Materials And Methods

This paper has been prepared by conducting laboratory test on compaction and strength behaviour of soil treated with alkaline effluents and results were compared to soil treated with tap water. Black Cotton Soil, silk dyeing effluents were used for the present investigation. Black Cotton Soil is collected from open method of soil exploration at location Kadur, Chikkamagalur district, Karnataka state, India at a depth of 1.6m from normal ground level. The obtained soil is pulverised and soil passing through the 425µ IS sieve used for the present investigation. The alkaline effluent is collected at the outlet point in the silk dyeing industry at Vijayapura, Bengaluru, India.

3.1 Sample preparation

Pulverised Black Cotton Soil has soaked in soaking chambers, containing silk dyeing alkaline effluent for a period of four days in order to stimulate field soil contamination condition. Then the soil which is collected from the soaked chambers were air dried and oven dried in a thermostatically controlled oven, there after soaked soil samples were taken for conduction of compaction and Unconfined Compressive Strength test. Typical soaking chambers are shown in photo 1.0. Two stages of experiment were conducted for both compaction and Unconfined Compressive Strength test. In the first phase oven dried field soil mixed with tap water to stimulate uncontaminated ground condition. In the second phase, to stimulate varying concentration of effluent in soil, the collected alkaline effluent has diluted from 10% to 90% and these diluted effluent preserved in separate cans as shown in photo 2.0. At each stage of experiment instead of distilled /tap water, diluted effluents which are preserved in respective cans are used for compaction and Unconfined Compressive Strength test. The physical and chemical properties of Black Cotton expansive soil shown in Table 1.0 and Table 2.0. Chemical properties of effluents are shown in Table 3.0.

Photo 1.0 Typical pictorial representation of Black Cotton Soil treated (soaked) in Alkaline effluent

Photo 2.0 Diluted Alkaline effluent in isolated condition

Table 1.0 Physical properties of Expansive soil

Soil Index	Values
Natural moisture content(%)	8.5
Liquid Limit (%)	77.00
Plasticity Index (%)	54.00
Gravel (%)	0.40
Sand (%)	23.40
Silt size fraction (%)	34.20
Clay size fraction (%)	42.00
Classification of soil	CH
Compaction test OMC (%) MDD (kN/m^3)	 25.80 15.40
Unconfined Compressive Strength (kN/m^2)	230

Table 2.0 Chemical properties of Expansive Black Cotton Soil

Parameters	Results
Calcium Oxide as CaO, (% by mass)	2.80
Magnesium Oxide as MgO, (% by mass)	1.2
Silicon Dioxide as SiO_2, (% by mass)	64.1
Iron Oxide as FeO_3, (% by mass)	5.6
Aluminium Trioxide as Al_2O_3, (% by mass)	8.43
Loss on Ignition, by mass at 900^0C	8.8
Sodium Oxide as NaO_2, (% by mass)	0.086
Potassium Oxide as K_2O, (% by mass)	0.35
Manganese Oxide as MnO, (% by mass)	0.03
Nitrogen as N_2O, %	0.12

Table 3.0 Chemical properties of effluent

Properties	100% concentrated Effluent	30% concentrated Effluent	Water (Tap)
pb (μg/l)	232.11	121.07	0.136
Cd (μg/l)	381.63	218.16	0.021
Al (μg/l)	241.05	130.14	0.056
Na (mg/l)	359.80	160.60	28.00
K (mg/l)	10.30	4.90	0.30
Cr (mg/l)	1.29	0.41	0.01

IV. Results And Discussion

From Fig 1.0 it is observed that Black Cotton Soil treated with varying percentage of alkali effluent reduces the maximum dry density of soil for all alkaline concentration, however, Black Cotton Soil treated with 30% alkaline effluent shows marginally increase in maximum dry density on compared with Black Cotton soil treated with tap water as well as other percentages of alkali effluent. This may be because of reduction in workability of Black Cotton Soil treated with most of percentage of effluent due to formation of cluster which increases the volume of voids space by reducing volume of soil and that volume occupied by water/air which reduces the density of matrix. Hence density reduces and moisture holding capacity in between cluster increase thereby optimum moisture content increases. However, this mechanism is having lower influence at soil treated with 30% alkali effluent (by weight of soil). Density increases in matrix due to increase in formation of cluster and elimination of 100% cluster in not found. This factor results in increase in moisture holding capacity.

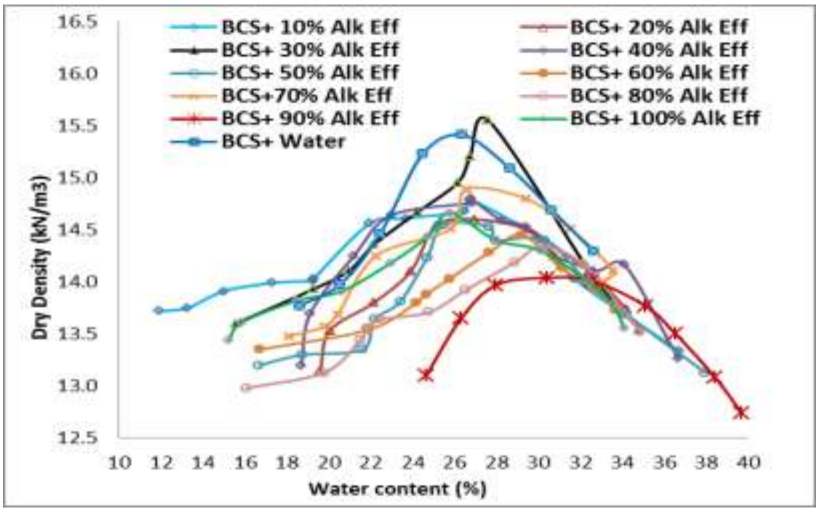

Fig 1.0 Unit weight – water content of Black Cotton Soil (BCS) treated with varying concentration of alkali effluent

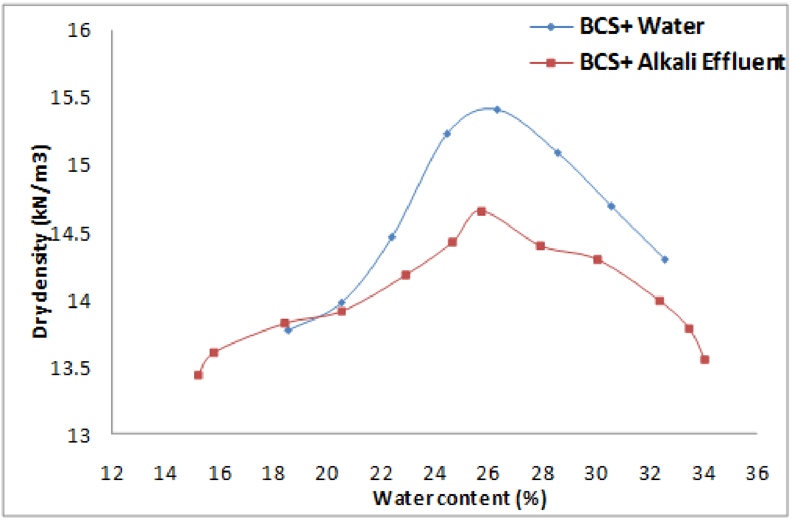

Fig 2.0 Unit weight –water content of Black Cotton Soil (BCS) treated with optimum concentration of alkali effluent

A comparative study has been carried out by comparing soil treated with tap water with alkaline effluent. As shown in the Fig 2.0, it is observed that Black Cotton Soil treated with alkaline effluent shifts the compaction curve to the right of optimum on compared with Black Cotton Soil alone with tap water.

Fig 3.0, it is observed that Black Cotton Soil treated with varying percentage of alkali effluent to Black Cotton Soil reduces the unconfined compressive strength of soil for all combination except for 30% alkaline effluent (by weight of soil). The reduction in strength in most of the combination is due to poor workability and formation of lumps in the Black Cotton Soil with alkaline matrix, which leads to lack of confining makes the disintegration of clusters have unconfined strength carrying capacity is less than the soil alone. On the other hand, Black Cotton Soil with 30% alkali effluent (by weight of soil) formation of cluster and strengthening of cluster with increased curing period leads to improvement in strength on compared with soil alone.

The improvement of unconfined compressive strength of soil treated with admixture can be represented in terms of Strength Gain Number (SGN) proposed by Ramesh et.al (2010)[5].
According to them,

$$SGN = \frac{Qa - Qt}{Qt} \qquad (1)$$

From the Strength Gain Number, it is observed that soil treated with 10% to 90% alkali effluent, there is a reduction in Strength Gain Number except for soil with 30% alkali effluent. At 30% alkali effluent there is remarkable progressive improvement in Strength Gain Number for all curing periods. This may be due to optimal combination of alkali effluent with available opposite charges in the effluent and soil. In presence of effluent formation of new compound called calcium alumina silicate which is a gelatinous compound which enhances the strength behaviour. Hence the Strength Gain Number remarkably improves at that combination.

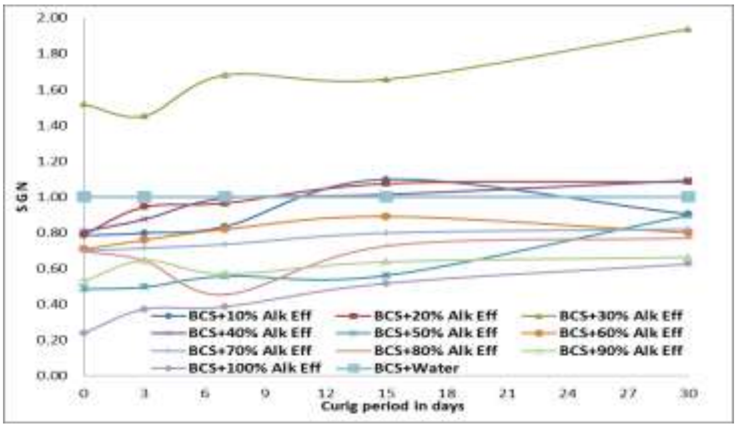

Fig 3. Variation of Unconfined Compressive Strength of Black Cotton Soil (BCS) treated with water alone and different percentages of alkali effluent with varying curing period

V. Conclusions

Based on the experimental investigation and analysis of investigated results following conclusions were drawn

1) Black Cotton Soil with tap water is having higher maximum dry density on compared with Black Cotton Soil treated with varying percentages of alkaline effluent but exception for 30% alkaline effluent.
2) Unconfined compressive strength test on Black Cotton Soil treated with 30% alkaline effluent (by weight of soil) is found to be optimum upto 30 days curing due to formation of strong gel bond.

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