



UNCONFINED COMPRESSIVE STRENGTH VS PLASTICITY INDEX BEHAVIOR OF EXPANSIVE SOIL USING INDUSTRIAL EFFLUENTS

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Abstract

Ground Pollution is perpetuated by humans due to many reasons. Industrial activity is necessary for the socio-economic progress of a country, but at the same time, it generates large amount of solid and liquid wastes. Among various means available, disposal through land is simple and widely used. All types of pollution have either direct or indirect effect on soil properties. Behaviour of any contaminant in soil depends upon the Physical and Chemical properties of the contaminant as well as its interactivity with that of soil. The effect of tannery effluent on compaction, Plasticity, Swelling, Strength Characteristics, Unconfined Compressive Strength vs Plasticity Index and California Bearing Values of Black Cotton Soil has been presented in this paper. The soil used in this investigation falls under "SC" group as per I.S. Classification and its Differential Free Swell Index is 80% indicating very high degree of expansiveness. The tannery effluent used in this investigation is a colourless liquid and soluble in water. It has a sour taste and a pungent smell.

1 INTRODUCTION

The index and engineering properties of the ground gets modified in the vicinity of the industrial plants mainly as a result of contamination by the industrial wastes disposed. The major sources of surface and subsurface contamination are the disposal of industrial wastes and accidental spillage of chemicals during the course of industrial operations. The leakages of industrial effluent into subsoil directly affect the use and stability of the supported structure.

Extensive damage to the floors, pavements and foundations of a light industrial building in Kerala State was reported by Sridharan et al. (1981). Joshi et al. (1994) reported that severe damage occurred to the interconnecting pipe of a phosphoric acid storage tank in particular and also to the adjacent buildings due to differential movements between pump and acid tank foundations of fertilizer plant in Calgary, Canada. A similar case of accidental spillage of highly concentrated caustic soda solution as a result of spillage from cracked drains in an industrial establishment in Tema, Ghana caused considerable structural damage to a light industrial building in the factory, in addition to localized subsidence of the affected area [Kumaplay & Ishola (1985)]. Therefore, it is better to start ground monitoring from the beginning of a project instead of waiting for complete failure of the ground to support human activities and then start the remedial actions.

Black cotton soils have high shrinkage and swelling characteristics. In general, these soils are very much sensitive to changes in environment. The environment includes the stress system, the chemistry of pore water in the system, the seasonal variations in ground water table and temperature variations.

Hence, an attempt is made in this investigation to study the effect of Tannery effluent on the Geotechnical Properties of a black cotton soil. MATERIALS USED The soil used for this investigation is obtained from near Tirupati (India). The soil is classified as 'SC' as per I.S. Classification indicating that it is clayey sand. It is highly expansive as the Free Swell Index is 254.5%. The properties of the soil are given in Table- 1.

Tannery effluent is a colourless liquid and soluble in water in

proportions. It has sour taste and pungent smell. The chemical properties of the effluent are shown in Table 2.

2 PROCEDURE FOR CONTAMINATION

The soil from the site is dried and the pebbles and vegetative matter present, if any, are removed by hand. It is further dried and pulverized and sieved through a sieve of 4.75 mm to eliminate gravel fraction, if any. This dried and sieved soil is stored in air tight containers for use for contamination. The soil sample kept for contamination is mixed with different percentages of tannery effluent, from 0 to 100 per cent, in increments of 20 percent. The contaminated soil prepared thus is stored for a day in air tight containers for uniform distribution of tannery effluent.

Table-1 Properties of Soil

S.No	Property	Value
1	Atterberg Limits	
	(a) Liquid Limits	77%
	(b) Plastic limit	29.2%
	(c) Plasticity Index	47.8%
2	Compaction Characteristics	
	(a) Maximum dry Unit Weight	18.48kN/m ³
	(b) Optimum Moisture Content	13%
3	Specific Gravity	2.65

3 TESTS CONDUCTED

The following tests are conducted in the presented investigation:

Table -2 Chemical composition of tannery effluent

S.No.	PARAMETER	VALUE
1.	Color	Dark color liquid
2.	pH	3.15
3.	Chromium	250 mg/l
4.	chloride	496.3 mg/l
5.	Sulphite	152.8 mg/l
6.	Total Hardness	520 mg/l
7.	BOD	120 mg/lit
8.	COD	450 mg/lit
9.	Suspended Solids	1200 mg/lit

1. Liquid limit tests
2. Plastic limit tests
3. Differential Free Swell Index Tests
4. Compaction Tests
5. Unconfined Compressive Strength vs Plasticity Index

4 RESULTS AND DISCUSSION

The effect of tannery effluent in varying proportion with soil has been studied and the variation in Liquid Limit (LL), Plastic Limit (PL) and Plasticity Index (PI) for various mixes is presented in Fig. 1. It is found that as the percentage of tannery effluent increases the LL, PL, and PI of soil mix is decreased marginally.

The Optimum Pore- fluid Content (OPC) and Maximum Dry Unit Weight (MDU) for soil may vary with various proportions of tannery effluent. The results of the Standard Proctors Compaction tests for soil conducted at different percentages of tannery effluent are reported in Fig. 3. The bottom most curve corresponds to 0 % of tannery effluent followed by 20%, 40%, 60%, 80% and 100% respectively. From these curves, it is seen that the peak points are shifted towards right with per cent

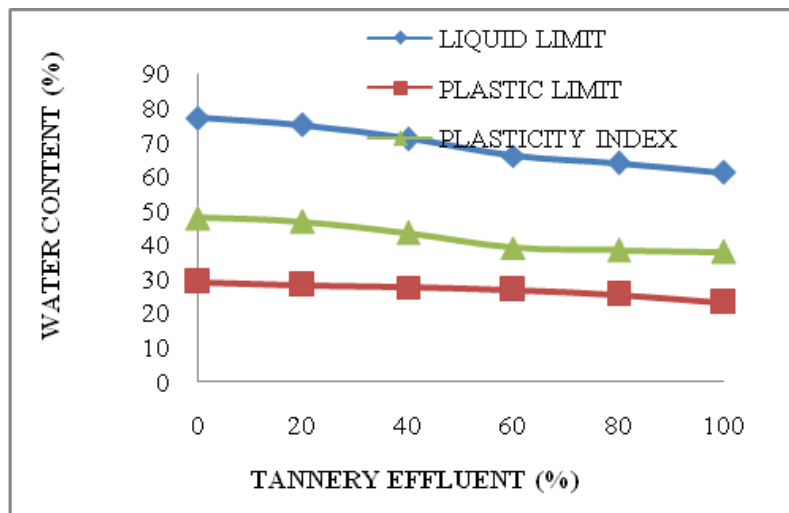


Figure 1: Variation of LL, PL and PI with per cent Tannery Effluent

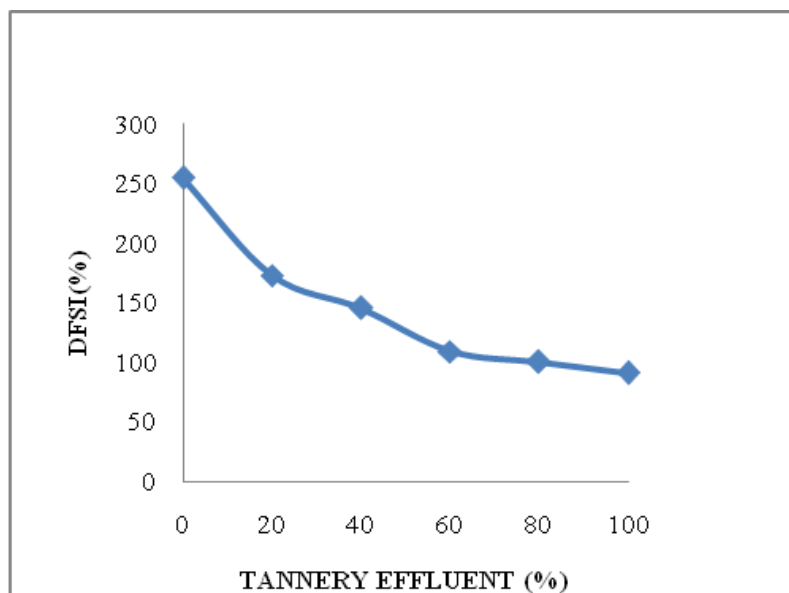


Figure 2: Variation of DFSI with the percent Tannery Effluent (%)

increase in effluent. The relationship between optimum pore fluid content and different percentages of tannery effluent is shown in Fig.4. It is found that the Optimum Pore fluid Content (OPC) increases with per cent increase of tannery effluent. The per cent decrease in OPC for 100% of tannery effluent is about 10.4%.

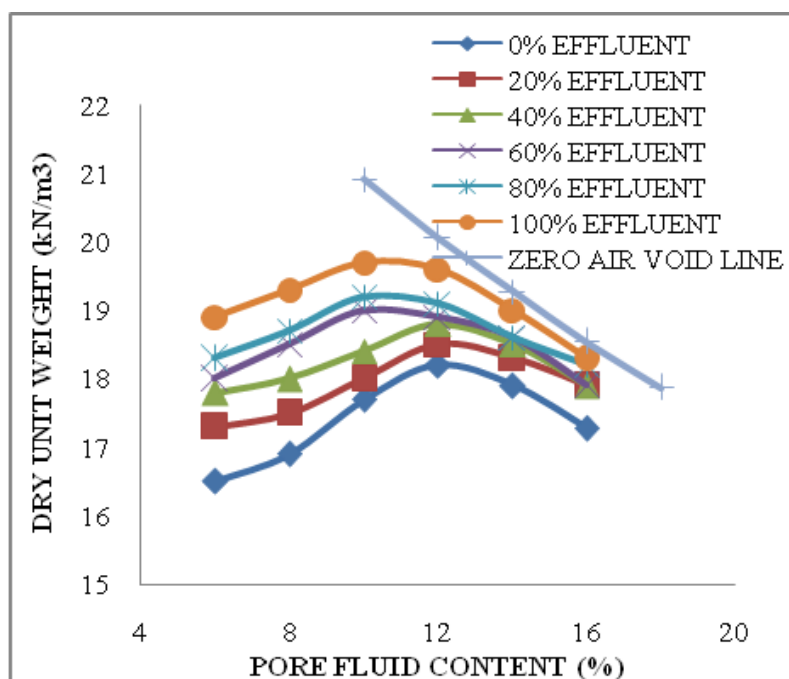


Figure 3: Compaction Curves for different Percentages of Effluent

The variation in maximum dry unit weight with percentage of tannery effluent is shown in Fig.4. From the figure, it is seen that the maximum dry unit weight decreases slightly with the increase in percentage of tannery effluent. The percentage decrease in MDU at 100% of tannery effluent is about 6 %.

The UCS values at various Plasticity index for different pore fluid content ratios are shown Table 3. The variation in UCS at different percentages of Plasticity index for different pore content ratios are shown in 5. From the figure it is observed that as the plasticity index increases the UCS values of treated soil also increases irrespective of pore fluid content ratio. The UCS values

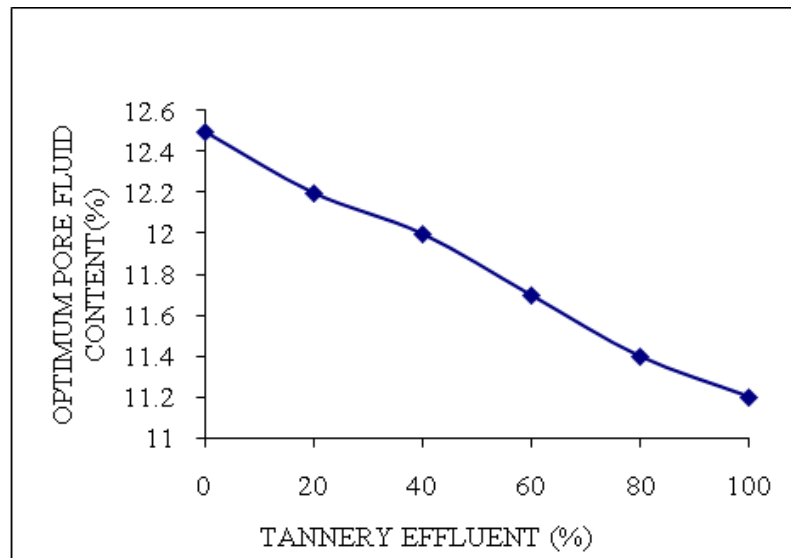


Figure 4: Variation of OPC with Per cent Tannery Effluent

decreases as the pore fluid content passes from dry side of optimum to wet side of optimum irrespective of plasticity index values. The maximum decrease in UCS value occurs at 100% Tannery effluent at Plasticity index=38.0 for pore fluid content =1.10 and it is equal to 72.5 kN/m²

Table 3: UCS Pore Fluid Content Ratio vs Plasticity Index

EFFLUENT (%)	PLASTICITY INDEX	UCS PORE FLUID CONTENT RATIO				
		0.9	0.95	1.0	1.05	1.10
0	47.8	252.82	174.76	172.8	148.6	86.2
20	46.8	235.62	172.86	168.1	142.1	84.9
40	43.5	223.42	170.26	164.4	140.1	80.8
60	39.1	213.72	164.96	161.2	137.5	76.8
80	38.5	195.72	157.76	154	130.5	73.6
100	38	182.52	150.56	146.2	126.9	72.5

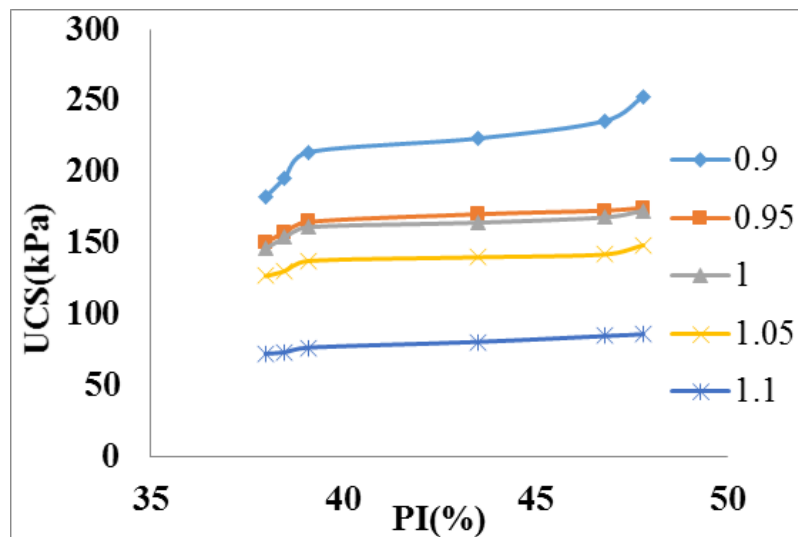


Figure 5: UCS for different pore fluid Content ratio vs Plasticity Index

5 CONCLUSIONS

The rapid growth in population and industrialization cause generation of large quantities of effluents. The bulk effluents generated from industrial activities are discharged either treated or untreated over the soil leading to changes in soil properties causing improvement or degradation of engineering behaviour of soil. If there is an improvement in engineering behaviour of soil, there is a value addition to the industrial wastes serving three benefits of safe disposal of effluents, using as a stabiliser and return of income on it. If there is degradation of engineering behaviour of soil then solution for decontamination is to be obtained. Based on experimental study the following conclusions are drawn. If increasing Tannery effluent Liquid limit and Plastic limits are decreased. The UCS values decreases as the pore fluid content passes from dry side of optimum to wet side of optimum irrespective of plasticity index values. The maximum decrease in UCS value occurs at 100% Tannery effluent at plasticity index=38.0 for pore fluid content =1.10 and it is equal to 72.5

kN/m²

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