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Effects of Textile Effluent on the Differential Free Swell Index of Expansive Soil

Phani Kumar Vaddi[1], T.Balaji Tilak[2], N.AnandVeera Kumar[3], K.Sumanth Kumar[4]

[1]Assistant Professor, Dept. of Civil Engineering, Gudlavalleru engineering College, Gudlavalleru,Krishnadt,A.P

[2]IV B.Tech, student, Dept. of Civil Engineering, Gudlavalleru engineering College, Gudlavalleru,Krishnadt, A.P

[3]IV B.Tech, student, Dept. of Civil Engineering, Gudlavalleru engineering College, Gudlavalleru,Krishnadt, A.P

[4]IV B.Tech, student, Dept. of Civil Engineering, Gudlavalleru engineering College, Gudlavalleru,Krishnadt, A.P

***ABSTRACT** - The rapid growth in population and industrialization cause generation of large quantities of effluents. The bulkeffluents 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 thethree benefits of safe disposal of effluent, using as a stabilizer and return of income on it. If there is degradationof engineering behaviour of soil then solution for decontamination is to be obtained. Hence an attempt is madein this investigation to study the effect of Textile effluent on the Differential free swell index Value of an expansive soil.*

***Key Words:**Expansive soil, textile effluent, Liquid limit, plastic limit, plasticity index and Differential free swell index.*

I. Introduction

The Index and Engineering properties of the ground gets modified in the vicinity of the industrialplants mainly as a result of contamination by the industrial wastes disposed. The major sources ofsurface and subsurface contamination are the disposal of industrial wastes and accidental spillage ofchemicals during the course of industrial operations. The leakage of industrial effluent into subsoildirectly affects the use and stability of the supported structure. Results of some studies indicate thatthe detrimental effect of seepage of acids and bases into sub soil can cause severe foundation failures.

Extensive cracking damage to the floors, pavement and foundations of light industrial buildings in afertilizer plant in Kerala state was reported by Sridharan (1981).Severe damage occurred tointerconnecting pipe of a phosphoric acid storage tank in particular and also to the adjacent buildingsdue to differential movements between pump and acid tank foundations of fertilizer plant in Calgary,Canada was reported by Joshi (1994). A similar case of accidental spillage of highly concentratedcaustic soda solution as a result of spillage from cracked drains in an industrial establishment inTema, Ghana caused considerable structural damage to a light industrial buildings in the factory, inaddition to localized subsidence of the affected area has been reported by Kumapley (1985).

Therefore, it is a better to start ground monitoring from the beginning of a project instead of waitingfor complete failure of the ground to support human activities and then start remedial actions.

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In many situations, soils in natural state do not present adequate geotechnical properties to be used as road service layers, foundation layers and as a construction material. In order to adjust their geotechnical parameters to meet the requirements of technical specifications of construction industry, studying soil stabilization is more emphasized. Hence an attempt has been made by researchers to use industrial wastes as soil stabilizers so that there is a value addition to the industrial wastes and at the same time environmental pollution can also minimized.

Hence an attempt is made in this investigation to study the effect of Textile effluent on the Differential free swell index of an expansive soil.

II. Experimental Investigations

2.1. Materials used

2.1.1. Soil

Expansive soils due to its swelling nature it causes lot of damages to Civil Engineering structures which are constructed over them. These type of soils are very sensitive to changes in environment such as change in applied stress, Pore fluid chemistry and its surrounding environmental conditions. Hence expansive soil is considered for investigation.

The soil used for this investigation is obtained from Pamarru, Krishna district. The dried and pulverized material passing through I.S.4.75 mm sieve is taken for the study. The properties of the soil are given in Table.1. The soil is classified as “CH” as per I.S. Classification (IS 1498:1970) indicating that it is inorganic clay of high plasticity. It is highly expansive as the Differential Free Swell Index (DFSI) is 191.8%.

Table 1

TABLE 2.Properties of the Untreated Soil

SI. No.	Property	Value
1.	Grain size distribution	
	(a)Gravel (%)	0
	(b)Sand (%)	2
	(c)Silt & Clay (%)	98
2.	Atterberg Limits	
	(a) Liquid Limit (%)	84
	(b)Plastic Limit (%)	36
	(c) Plasticity Index (%)	48
3.	Differential free swelling Index (%)	191.8
4.	Specific gravity	2.73
5.	pH value	8.83

2.1.2Textile effluent

Textile effluent is a coloured liquid and soluble in water. The chemical properties of the effluent are shown in Table 3.

TABLE 3 Chemical Composition of Textile Effluent

SI.No.	PARAMETER	VALUE
1.	Colour	Blue
2.	pH	8.83
3.	Sulphates	260 mg/l
4.	Chlorides	380 mg/l
5.	Acidity	0
6.	Alkalinity	2400 mg/l
7.	Suspended solids	1500 gm
8.	Total solids	13.50gm
9.	BOD	150 mg/l
10.	COD	6200 mg/l

III. Procedure For Mixing

The soil from the site is dried and hand sorted to remove the pebbles and vegetative matter if any. It is further dried and pulverized and sieved through a sieve of 4.75mm to eliminate gravel fraction if any. The dried and sieved soil is stored in air tight containers and ready to use for mixing with effluents.

The soil sample so prepared is then mixed with solutions of different concentrations of Textile effluent. The percentage varied from 20 to 100% in increment of 20%.The soil - effluent mixtures are mixed thoroughly before testing.

IV. Tests Conducted On Treated Soil

The following tests have been conducted in this investigation.

4.1 Plasticity Characteristics

For the studying the plasticity characteristics, Liquid Limit and plastic Limit tests have been carried out for the Soil under treated and untreated conditions.

4.1.1 Liquid Limit

Liquid limit tests are conducted at various percentages of Textile effluent. About 120 g of an air-dried sample passing through 425-µ I.S. sieve is taken in a dish and mixed with certain amount of water to form a uniform paste. A portion of this paste is placed in the cup of the liquid limit device and surface is smoothened and leveled with a spatula to a maximum depth of 10 mm. A groove is cut through the sample along the symmetrical axis of the cup, preferably in one stoke, using a standard grooving tool.

After the soil pat has been cut by a proper grooving tool, the handle is turned at a rate of 2 revolutions per second until the two parts of the soil sample come into contact at the bottom of the groove along a distance of 12mm .About 15g of soil near the closed groove is taken for water content determination. The liquid limit is the water content at which the soil is sufficient fluid to flow when the device is given 25 blows. As it is difficult to get exactly 25 blows for the sample to flow ,the test is conducted at different water contents so as to get blows in the range of 10 to 40.The soil in the cup is transferred to the dish containing the soil paste and mixed thoroughly after adding more water. The soil sample is again taken in the cup of the liquid limit device and the test is repeated.

4.1.2 Plastic Limit

About 30g of soil, passing through 425-µ I.S. Sieve, is taken in evaporating dish. It is mixed thoroughly with water till it becomes plastic, and can be easily moulded with fingers. About 10g of the plastic soil mass is taken in one hand and a ball is formed. The ball is rolled with fingers on a glass plate to form a soil thread of uniform diameter as shown in Fig 2.3. The rate of rolling is kept about 80 to 90 strokes per minute. If the diameter of the thread becomes approximately 3mm and if it starts just crumbling that water content is known as the plastic limit.

4.1.3 Plasticity Index

Plasticity index is the range of water content over which the soil remains in the plastic state. It is equal to the numerical difference between the liquid limit and the plastic limit.

4.2 P^H

The object is to determine the Hydrogen ion concentration, designated as P^H of soils.The pH value of a solution is measure of its acidity or alkalinity. P^H equal to 7 indicates a neutral solution, less than 7 as acidic and greater than 7 as alkaline. The pH value is equal to the common logarithm of the reciprocal of the Hydrogen ion concentration.

$P^H=\log_{10}(1/H^+)$

Where H = Hydrogen ion concentration (moles/liter)

The P^H value can be determined by the following methods.

Electrometric method, calorimetric and indictor paper methods. The electrometric is the standard method of accurate work.

The electrometric method is based on the principle (Housel, 1964) that the solution under test can be considered as an electrolyte of a voltaic cell.

10g of pulverized and representative soil sample passing through 425-µ I.S. sieve is taken in 100 ml beaker and 100 ml water is added. The suspension is stirred for a few minutes and covered with glass cover and is allowed to stand for a few hours (at least one hour), preferably overnight. The suspension is stirred again immediately before testing.

The buffer solution having a P^H value nearer to the expected P^H value of the soil suspension is used. The electrodes are washed with distilled water and then immersed in the soil suspension. Two or three reading of the P^H of the suspension are taken with brief stirring in between the readings. The readings only when the P^H meter has reached equilibrium, which may take about 1 minute, are recorded. These readings, which are taken, have to agree with in ±0.05 pH units. The same procedure has been followed for other percentages of Textile effluent.

4.3 Differential Free Swell Index

This test is conducted on the expansive soil treated with Textile effluent in varying percentages from 0% to 100% in increments of 20%. Two samples of the dried soil weighing 10g each passing through 425-µ I.S. sieve are taken. One sample is put slowly in a 100 ml graduated glass cylinder having kerosene (a non-polar liquid). The other sample is similarly put in another 100 ml glass cylinder having distilled water. Both the samples are left for 24hours and then their volumes are noted. Differential Free Swell Index is calculated by the formula given below.

$$DFSI = \frac{V_1 - V_2}{V_1} X100$$

V_1 = Soil volume in distilled water
V_2 =Soil volume in kerosene

V. Results And Discussions

5.1Liquid Limit

The results of liquid limit tests conducted at different percentage of Textile effluent are presented in Fig.5.1. From the figure,it is observed that liquid limit at 0% of Textile effluent is higher when compared to other percentages and the value is 84%. The maximum decrease in Liquid limit is 30.95% which occurs at 100% of Textile effluent. There is a relation between compression index and liquid limit of the soil. Therefore, consolidation settlements are decreased due to Textile effluent.

5.2Plastic Limit

Plastic limit values of different percentages of Textile effluent are presented inFig 5.1.The plastic limit value of the untreated soil is 36%. From the figure, it is found that plastic limit value of the treated soil decreases with increase in percentage of Textile effluent.

5.3Plasticity Index

Plasticity index values are calculated for different percentages of Textile effluent and are presented in Fig 5.1. The plasticity index of untreated soil is 48%. The plasticity index values of the treated soil for all percentages of Textile effluent are smaller than that of the untreated soil.

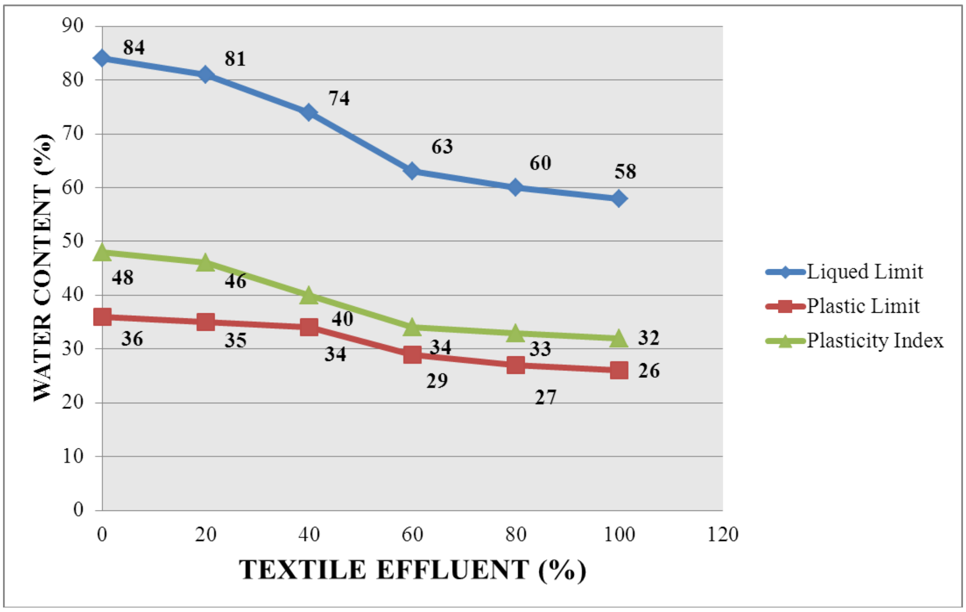

FIG 5.1: Variation of Liquid Limit, Plastic Limit, Plasticity Index with Percentage of Textile Effluent

5.4 P^H

P^H values for the soil treated with different percentages of Textile effluent are measured and are presented in Fig 5.2. The P^H value of untreated soil is 8.83.From the Fig 5.2, it is observed that, the P^Hvalue of treated soil decreases with per cent increase in Textile effluent.

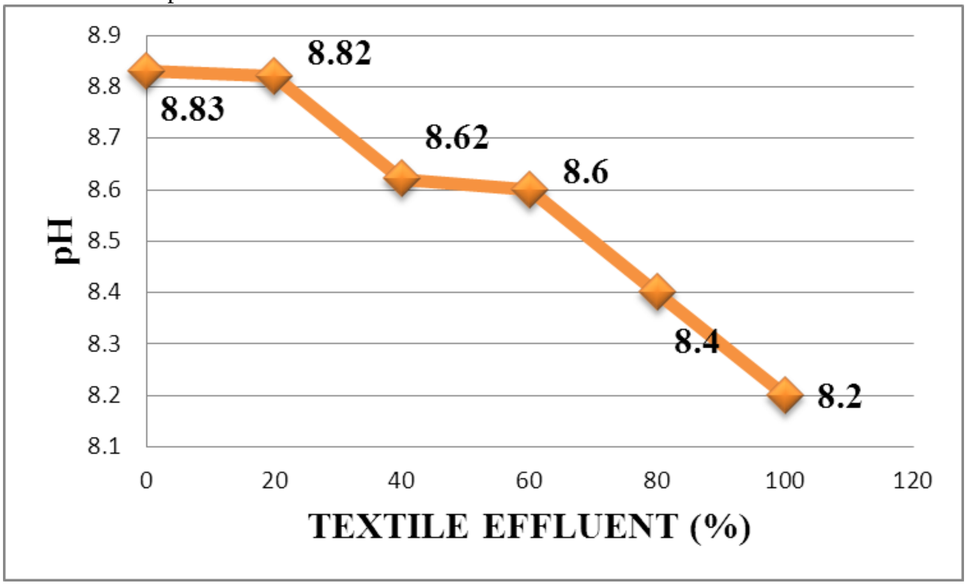

FIG 5.2: Variation of Ph with Percentage of Textile Effluent

5.5 Differential Free Swell Index

The variation of Differential Free Swell Index with per cent Textile effluent is shown in Fig 5.3. From the figure, it is observed that the Differential Free Swell Index decreases with percent increase in Textile effluent. The percent decrease in the Differential Free Swell Index is about 41.61 at 100% of Textile effluent.

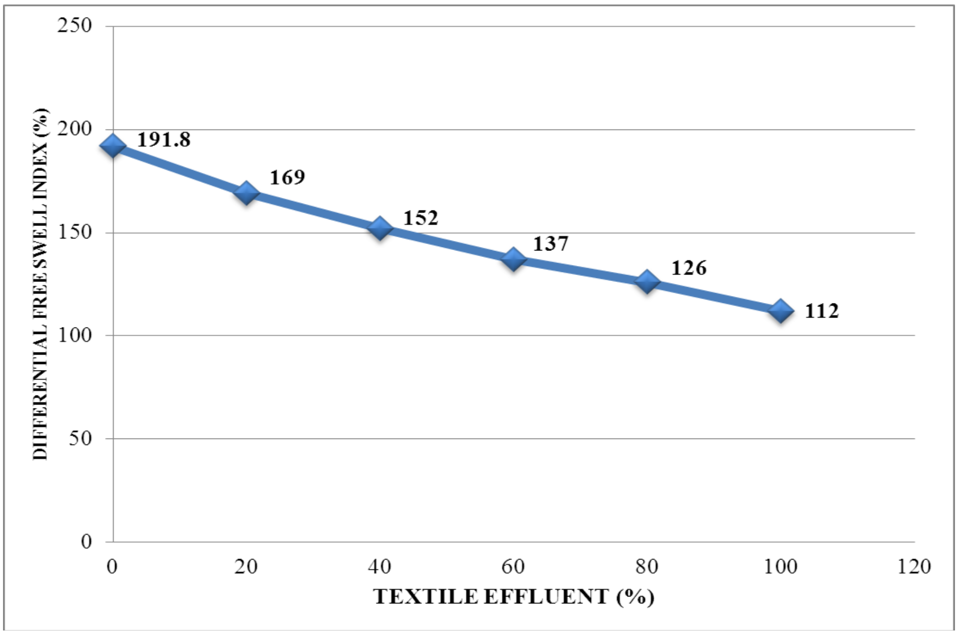

FIG5.3: Variation of Differential Free Swell Index with Percentage of Textile Effluent

VI. Summary And Conclusions

Textile industry produces considerable amount of pollutants, since it is a wet processing system. The wide variety of polluting chemicals and dye stuffs is utilized in a Textile industry. The dyeing effluent treatments are more complex than any other industrial waste water purification, because of the fact no two dyeing effluents are alike in character, nor can two effluents be purified or treated by exactly the same treatment. Effluent from dyeing unit varies from time to time based on the change in market demand.

Hence, in this investigation the effect of Textile effluent on plasticity, P^H and Differential Free Swelling Index, of expansive soil treated with Textile effluent has been given due importance.

- Both the Liquid limit and Plastic limit values of the treated soil decrease with increase in percentage of Textile effluent.
- The Plasticity index values of treated soil for all percentages of Textile effluent are lower than that of the untreated soil.
- The addition of Textile effluent reduces the pH of the soil slightly.
- Differential Free Swelling index with increase in percent Textile effluent.
- The treated soil is less susceptible to heaving and shrinkage at 100% Textile effluent.

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