ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 3, March 2017

Comparative Study on CBR Values of Expansive Soil Using Different Industrial Effluents

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***Abstract:*— In this paper the effect of industrial effluents on CBR behavior has been studied. The soil used in this investigation is classified as "SC" as per Indian Standard Classification system. It is highly expansive nature as the differential free swell index (DFSI) is about 255%.The California bearing ratio tests are conducted on the soil treated with tannery and battery effluents at different percentages from 20 to 100% in increment of 20% Tests are also conducted on untreated soil for comparison. The results show that CBR values are increased for tannery effluent and CBR strength is decreased for battery effluent. These results helps for further study in different accepts.**

***Keywords:*-- tannery effluent, battery effluent and CBR values.**

I. INTRODUCTION

Industrialization and urbanization play a key role for developing a country. Due urbanization and increasing population, number of industries came. These industries are producing large amount of effluents (treated or untreated) and contamination of land and water streams through improper treatment practices. Contamination of soil is a serious issue because it is changes the index and engineering properties of soils. Modification of soil properties will influence on foundation, highways, and structures. Safe disposal of wastes is one of the primary important factors that has become the present paramount. On other hand, soil stabilization of expansive soils is also important. However, some industry solid waste/effluents like fly ash, stone dust, tire chips, rice husk ash are helps for soil stabilization.

Extensive damage to the floors, pavements and foundations of a light industrial building in Kerala State was reported by Sridharan et al. (1981, 2002). 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 and 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.

In this paper, tannery and battery effluents are mixed with soil to find the CBR values. These CBR values help for pavement design.

II. 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 (IS 1498:1970) 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 industry effluent is dark colored liquid and soluble in water. Battery effluent is a colorless liquid and soluble in water in proportions. The chemical properties of the effluents are shown in Table 2.

III. 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 mixed with different percentages of battery effluent and tannery effluent, from 0 to 100 percent, in increments of 20 percent and then stored for a day in air tight containers for uniform distribution of battery effluent.

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Table-1 Properties of Soil (after Reddy 2011 and Naik 2012)

Property	Value
Atterberg Limits	
(a) Liquid Limits (b) Plastic limit (c) Plasticity Index	77% 30% 47%
Compaction Characteristics	
(a) Maximum dry Unit Weight (b) Optimum Moisture Content	18.48kN/m^3 12.8%
Specific Gravity	2.76

Table -2 Chemical composition of effluents (after Reddy 2011 and Naik 2012)

PARAMETER	VALUE	
	Tannery effluent	**Battery effluent**
Color	Dark color	White
pH	3.15	8.45
Sulphates	152.8 mg/l	250 mg/l
Chlorides	496.3 mg/l	30 mg/l
BOD	120 mg/l	110 mg/l
COD	450 mg/l	320 mg/l

In this investigation California bearing batio tests on expansive soil treated with tannery effluent and battery effluent varying from 0% to 100% in increment of 20% is carried out. The tests are conducted on remolded soil specimens at their respective optimum pore fluid content (OPC) and maximum dry unit weights and compacted according to Indian standard light compaction. Table 3 shows the optimum pore fluid content and maximum dry unit weights of two effluents (tannery and battery). CBR values helps to determine the strength of the subgrade and the thickness required for a flexible pavement. The results obtained by these tests are used in conjunction with empirical curves, based on experience for the design of flexible pavements. The California bearing ratio value is determined corresponding to both 2.5 mm and 5.0 mm penetrations, and the greater value is used for the design of flexible pavement.

Table 3 Optimum pore fluid content and maximum dry unit weights

Effluent (%)	Optimum Pore fluid Content		Maximum dry unit weight (kN/m^3)	
	Tannery	Battery	Tannery	Battery
0	12.4	12.4	18.3	18.3
20	12.1	13.5	18.6	17.71
40	11.9	13.6	18.8	17.51
60	11.6	13.7	19.1	17.41
80	11.3	13.9	19.5	17.37
100	11.1	14.1	19.8	17.20

IV. RESULTS AND DISCUSSIONS

The test results of California bearing ratio values are presented for tannery and battery effluents. The load - penetration curves of treated and untreated soil obtained from California bearing ratio tests at different percentages of tannery and batter effluent are presented in Figure 1 and 2.

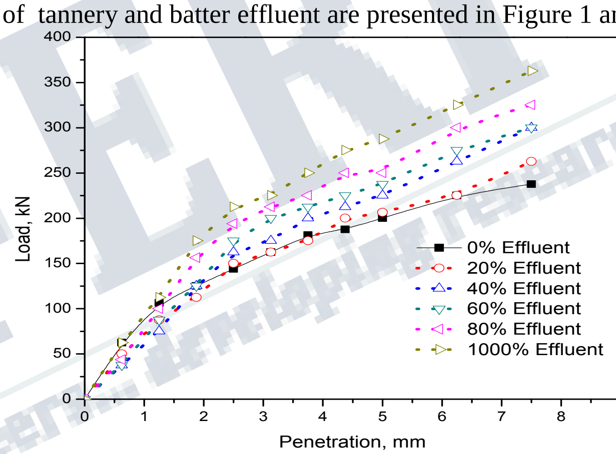

Fig.1: Load– Penetration curves of treated soil at different percentages of Tannery Effluent

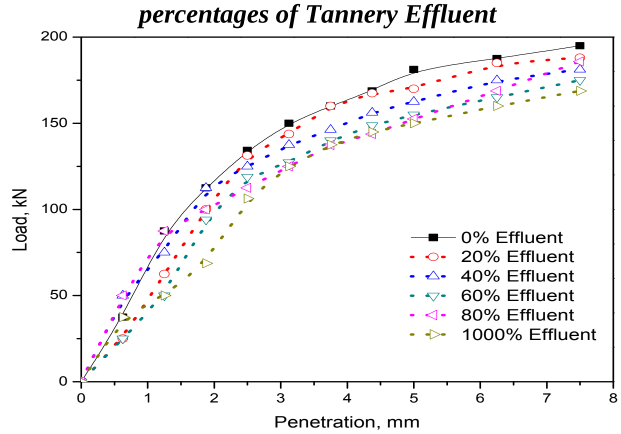

Fig.2: Load– Penetration curves of treated soil at different percentages of Battery Effluent

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The variation of the CBR values with different percentages of tannery and battery effluents are shown in Figure 3 and 4. From figures, it is observed that the maximum percent increase in CBR value at 2.5 mm penetration for 100% tannery effluent is about 50%. It is found that the maximum percent decrease in CBR value for 100% battery effluent is about 21%.

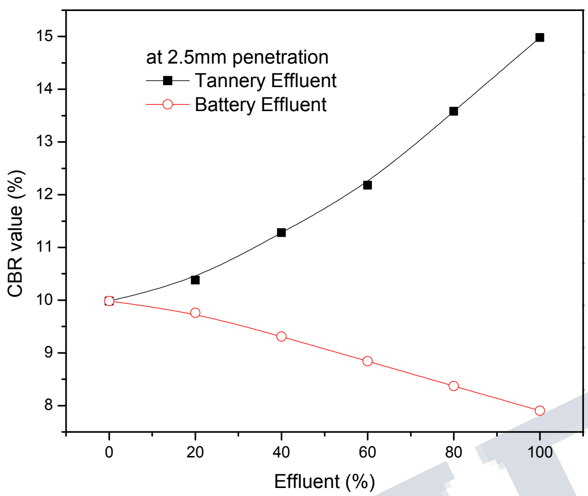

Fig.3 Variation of CBR values at 2.5 mm penetration at different percentages of Effluents

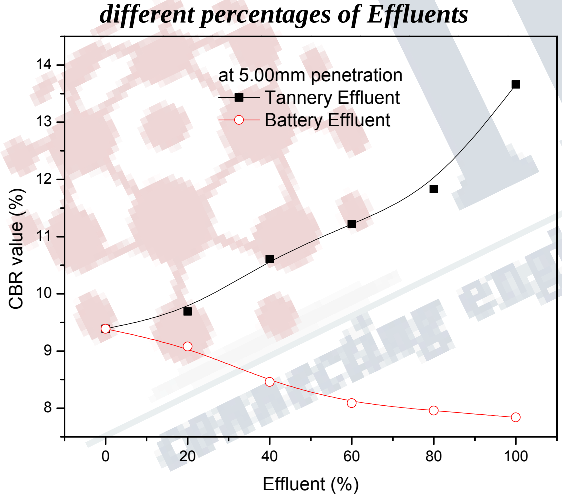

Fig.4 Variation of CBR values at 5.0 mm penetration at different percentages of Effluents

Further, CBR values are determined at 5.0 mm penetration for tannery and battery effluents. It is observed that the maximum for 100% tannery effluent is about 45.47%. It is found that the maximum percent decrease in CBR value for 100% battery effluent is about 16.50%.

V. CONCLUSION

In this investigation, an attempt has been made to study the effect of two industrial effluents (tannery and battery effluents) on CBR values of an expansive soil. From the results presented in this investigation, the following conclusions are drawn. CBR values are increased when soil mixed with tannery effluents. But when it is mixed with battery effluent CBR values are decreased. Further amylases is required to bring mechanism.

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