Study on the Geotechnical Characteristics of Contaminated Soil

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Abstract - *Due to industrialization the amount of effluent discharged in environment has increased rapidly with time. The safe disposal of these effluent is a major issue that is been faced all over the world. One of the major predicaments faced by geotechnical engineers around the world is land contamination. The effluent when it comes in contact with soil causes changes the engineering behaviour of the soil which may affect the stability of the foundation and pavements. In some cases the changes caused by these effluents can either improve or degrade the engineering behavior of soil. If there is an improvement in engineering behaviour of soil, there is a value addition to the industrial wastes serving the three benefits of safe disposal of effluent, using as a stabilizer and return of income on it. If there is degradation of engineering behavior of soil then solution for decontamination is to be obtained. Hence an attempt is made in this present study that the effect of certain Industrial effluents such as Soap effluent, on the plasticity, compaction characteristic and shear strength parameters of Shedi soil. Effluents were added in the percentage of 5%, 10%, 15%, 20% and 25% by the dry weight of the soil for a curing period of 7, 14 and 28 days. Results of the study shows that Soap Effluent increases the maximum dry density with decrease in optimum moisture content, lowers the liquid limit, plastic limit and higher the shrinkage limit. It can be inferred that the increase in percentage of soap effluent with increase in curing period causes the marginal variations in geotechnical properties of red soil. When soil interacts with industrial effluents, the interaction changes the pore fluid chemistry and subsequently the thickness of diffused double layer. These changes are likely to be reflected by variation in engineering properties.*

Key Words: Shedi Soil, Diffused double layer, Industrial effluent, Soap effluent.

1.INTRODUCTION

Geoenvironmental engineering is the application of newly developed environmental concepts in the geotechnical engineering. The development of modern life especially due to the connected of industries and other developments have given rise to large risks of soil contamination. With the industrial development in India, the waste management systems did not develop accordingly. Almost all industries are seen to discharge their wastes into water and on land without any treatment or after partial treatment. Indiscriminate disposal of liquid and solid wastes, especially on land, has caused serious environmental and also geotechnical problems. The inorganic and organic pollutants present in industrial effluents generally affect the geotechnical properties of soil. An understanding of the soil-pollutant interactions and the effect of various contaminants or industrial effluents on geotechnical properties of soils helps for assessing the suitability of ground soil for engineering purpose or initiate suitable measures to make the ground soil fit for construction. If there is an improvement in engineering behavior of soil, there is a value addition to the industrial wastes serving the three benefits of safe disposal of effluent, using as a stabilizer and return of income on it.

2. MATERIALS AND METHODOLOGY

A. Shedi Soil

The Shedi soil was procured from Bhatkal, Utter kannada district, Karnataka, which was collected from a borrow pit of 1.0m depth from the existing ground level. The soil sample has been tested in the laboratory to determine the engineering properties as per the relevant IS code procedure.

Table -1: Properties of Soil

SL .No.	Properties		Values
1	Grain Size Distribution	Gravel	0%
		Sand	52.60%
		Silt and Clay	47.40%
2	Specific Gravity (G)		2.28
3	Liquid Limit (WL)		41%
4	Plastic Limit (WP)		38%
5	Shrinkage Limit (WS)		35.3%
6	Optimum Moisture Content (O.M.C)		25%
7	Maximum Dry Density (M.D.D.)		13.52 kN/m^3
8	Cohesion		7 kN/m^3
9	Angle of friction		20°

B. Soap Effluent

In the present study the soap effluent is collected from Kozhikode, Kerala. The untreated effluent was manually collected from the soap industry ,in 20 liters plastic cans (air tight containers).

Table-2: Properties of Soap Effluent

Sl. No.	Parameter	Value (mg/l)
1	Sodium	361.8
2	Potassium	32.7
3	Calcium	24429
4	Chloride	854.9

Samples were collected in jute bags, air dried and transported to the laboratory. It is further dried and pulverized and sieved through a sieve of 4.75 mm to eliminate pebbles and vegetative matter, if any and divided soil samples into 6 portions. Soap effluent was added to each of the portions at 0 to 25% in increments of 5%. Soil-Soap effluent mixture was thoroughly mixed and stored in air container for different curing periods of 7, 14 and 28 days for allowing possible reaction. Further, the soil effluent mixtures were air dried for 48 hours before testing and all the tests were carried out as per the relevant Indian Standards.

3. RESULTS AND DISCUSSIONS

A. Effect on Liquid limit

The variation in liquid limit for different percentage and curing period is as shown in Figure 1. It was observed that the liquid limit decreased with increase in the percentage of effluent added, whereas with respect to curing period, liquid limit decreases up to a curing period of 14 days and then increased. The maximum reduced value of liquid limit is 36% for a curing period of 14 days.

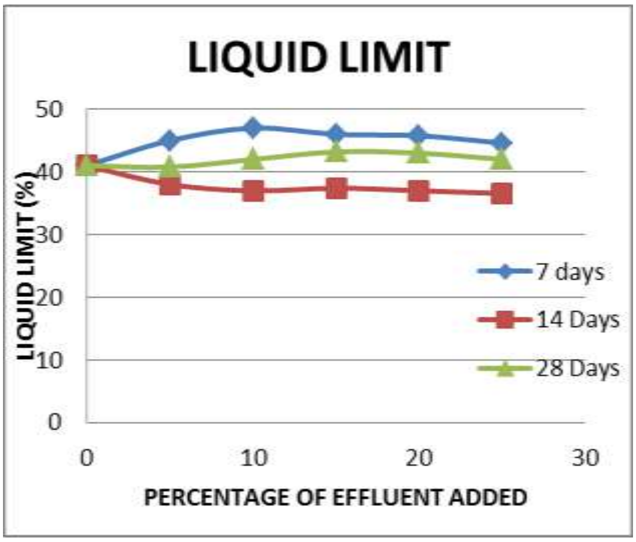

Fig. 1. Variation in liquid limit of red soil mixed with soap effluent

B. Effect on plastic limit

The variation in plastic limit for different percentage and curing period is as shown in Figure 2. It was observed that the plastic limit decreased with increase in the percentage of effluent added, whereas with respect to curing period, plastic limit decreases up to a curing period of 14 days and then increased. The maximum reduced value of plastic limit is 32% for a curing period of 14 days.

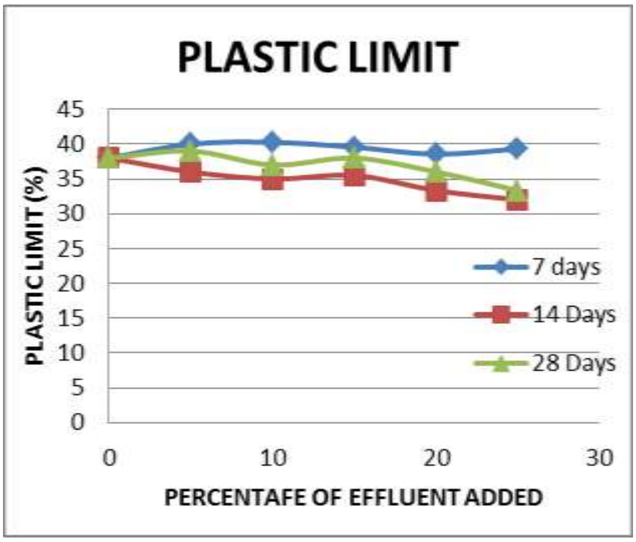

Fig. 2. Variation in Plastic limit of red soil mixed with soap effluent

C. Effect on Shrinkage limit

The variation in shrinkage limit for different percentage and curing period is as shown in Figure 3. It was observed that the variation in shrinkage limit is marginal and shrinkage limit increases with increase in percentage of effluent and with respect to curing period the shrinkage increased for curing period of 7 and 14 days and for 28 days.

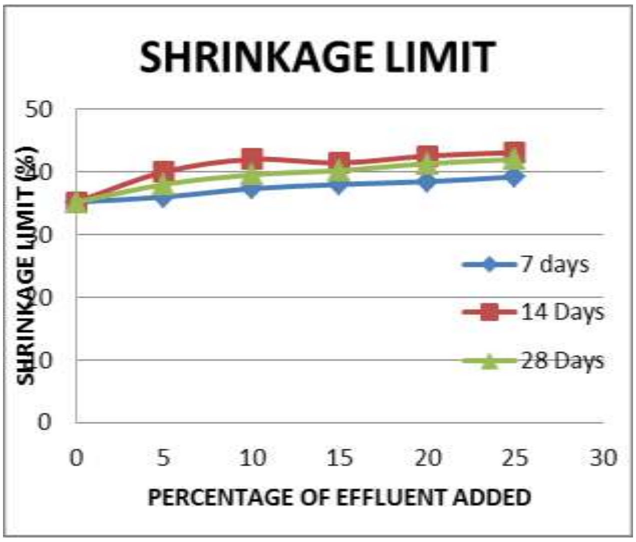

Fig.3. Variation in Shrinkage limit of red soil mixed with soap effluent

D. Effect on maximum dry density

The variation in maximum dry density for different percentage of effluent and curing period is as shown in Figure 4. It was observed that the maximum dry density slightly increase with increase in percentage of effluent added and curing period. The MDD increased from 10.58 kN/m^3 to 14.28 kN/m^3.

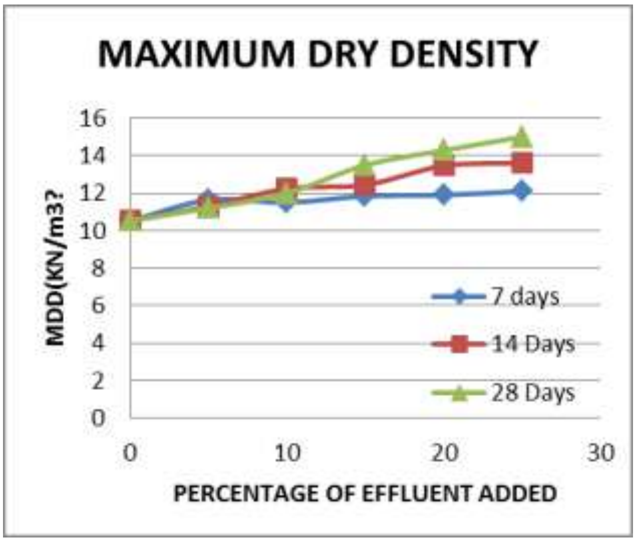

Fig.4. Variation in MDD of red soil mixed with soap effluent

E. Effect on optimum moisture content

The variation in optimum moisture content for different percentage of effluent and curing period is as shown in Figure 5. It was observed that the OMC decreased with increase percentage of effluent added and curing period the OMC decreased from 25% to 23.5%.

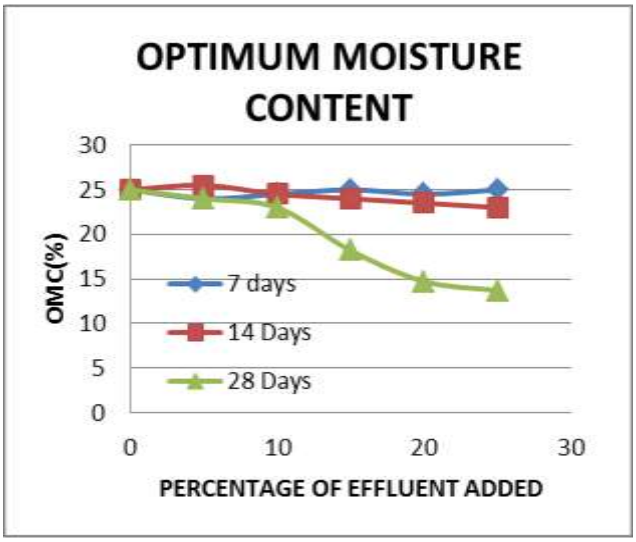

Fig. 5. Variation in OMC of red soil mixed with soap effluent

F. Effect on cohesion

The variation in cohesion for different percentage of effluent and curing period is as shown in Figure 7. It was observed that the cohesion increased by increase in percentage of effluent and increased with curing period. The cohesion increased from 14kN/m^2 to 16 kN/m^2

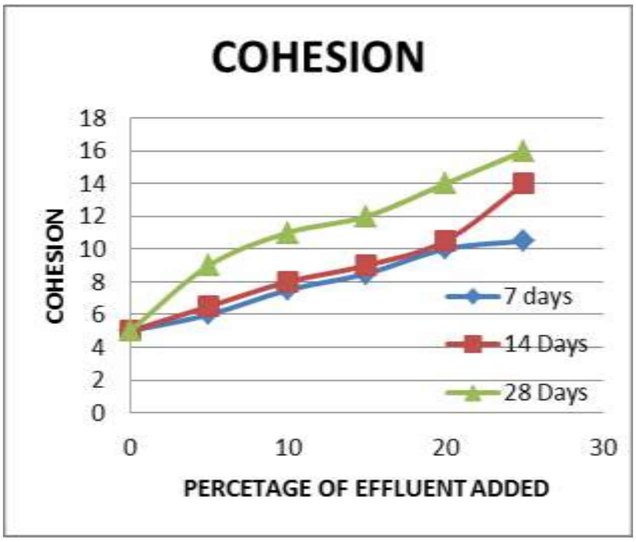

Fig. 6. Variation in Cohesion of red soil mixed with soap effluent

G. Effect on angle of internal friction

The variation in angle of internal friction for different percentage of effluent and curing period is as shown in Figure 8.It was observed that the angle of internal friction decreases by increase in percentage of effluent and curing period. The angle of internal friction decreased to 5°.

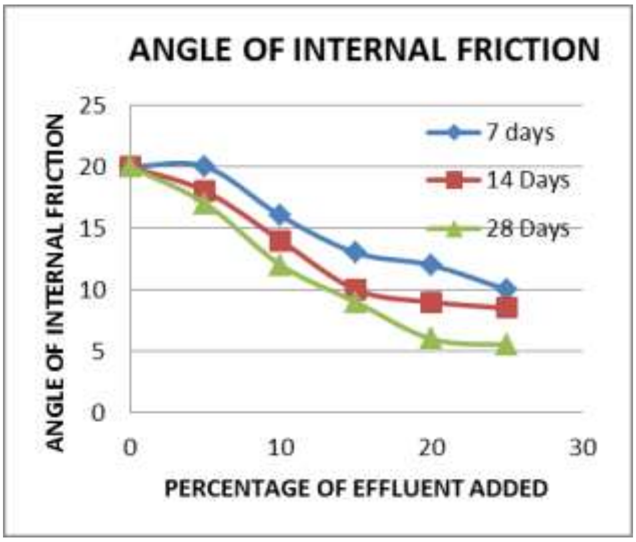

Fig. 7. Variation in Angle of Internal Friction of red soil mixed with soap effluent

II. MECHANISM INVOLVED IN SOIL-SOAP EFFLUENT MIXTURE

The following mechanisms are responsible for the observed variation in the geotechnical properties of contaminated Shedi soil:

1. For shedi soil treated with soap effluent it was observed that there was decrease in liquid limit and plastic limit with increase in percentage of effluent added up to curing period of 14 days a maximum reduced value of 36% and then increased. This is due to the replacement of monovalent cation by divalent Ca (2+) cation and the increase in liquid limit with curing period is due to flocculation of particle.
2. For shedi soil treated with soap effluent it was observed that there was increase in shrinkage limit with increase in percentage of effluent added and curing period.
3. It was observed that there was marginal variation in maximum dry density as well as the optimum moisture content. It was observed that there was slight decrease in OMC with increase in percentage of effluent and curing periods.
4. In the presence of high valence cation ($Ca2+$), the distance between the particle decreases by decreasing the repulsive force and increase in attractive force. Hence the particle pack better together because of which there is a slight increment in the dry density of soil.
5. Consequently on particle becoming closer will have decrease in water holding capacity because of which the optimum moisture content decreases.
6. The shear strength parameters, cohesion increased with increase in percentage of effluent added and curing period where as there was marginal decrease in angle of internal friction with increase percentage of effluent and curing period.
7. An increase in the valency of the exchangeable cation increases inters particle attractive forces while reducing the repulsive forces.
8. This leads to an increase in net attractive force in the system and in turn increases in the cohesion of the particle level which favors the development of more flocculent fabric.

3. CONCLUSIONS

1. The liquid limit decreased with increase in the percentage of effluent added; whereas with respect to curing period, liquid limit decreases up to a curing period of 14 days and then increased. The maximum reduced value of liquid limit is 36% for a curing period of 14 days.
2. The plastic limit decreased with increase in the percentage of effluent added; whereas with respect to curing period, plastic limit decreases up to a curing period of 14 days and then increased. The maximum reduced value of plastic limit is 32% for a curing period of 14 days.
3. The variation in shrinkage limit is marginal and shrinkage limit increases with increase in percentage of effluent and with respect to curing period the shrinkage increased for curing period of 7 and 14 days and for 28 days.
4. The maximum dry density slightly increases with increase in percentage of effluent added and curing period. The MDD increased from10.58 kN/m^3 to 14.28 kN/m^3.
5. The OMC decreased with increase percentage of effluent added and curing period .the OMC decreased from 25% to 23.5%
6. The cohesion increased by increase in percentage of effluent and increased with curing period. The cohesion increased from 14 kN/m^2 to 16 kN/m^2.
7. The angle of internal friction decreases by increase in percentage of effluent and curing period. The angle of internal friction decreased to 5°.
8. It can be inferred that upon addition of soap effluent to red soil, there is marginal variation in index, compaction and strength properties of soil.

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