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Atterberg's Limit and Shear Strength Haracterestics of Leachate Contaminated Lateritic Soil

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ABSTRACT

Landfill leachate is generated from liquids existing in the waste as it enters a landfill or from rainwater that passes through the waste within the facility. Most of the municipal solid waste generated is disposed in low lying areas, which eventually become open dumps, located in the outskirts of the city. After few years of dumping, these waste dumping yards get filled up and need to be abandoned. Meantime with urban development and expansion, these areas (dumping yards) come under a zone with serious scarcity of vacant land. Therefore, this areas need to be reclaimed for other purposes. Behaviour of such land containing municipal solid waste and contaminated by leachate are still not well understood under various loading conditions and thus a gap exist for predicting the engineering behaviour of structures constructed of/with municipal solid waste fills. Large areas of land are currently being used for this study. A laboratory testing program was carried out to determine the properties of leachate contaminated soils. MSW samples and leachate contaminated soil samples are used in this study.

The liquid limit and plasticity index of the lateritic soils increases with increase leachate concentration. For samples tested at the Proctor density, effective cohesion increases and effective friction angle decreases due to increase in leachate concentration. This is attributed due to the increase in clay content of lateritic soil after interaction with the leachate. This lead to increase in cohesion parameter and friction angle decreases. The present work deals with an attempt to study the effect of leachate on the Atterberg's limit, shear strength properties of lateritic soil.

Keywords : Atterberg's limit, Contamination, Lateritic soils, Leachate, Shear strength.

1.1 INTRODUCTION

The problems associated with solid waste management are many. Effective management is possible only when we appreciate the problems associated with waste disposal (solid or liquid). Any negligence in waste management will simply lead to numerous environmental problems including health hazards (affects).

Interaction of moisture with municipal solid waste (MSW), leachate is produced which is a hazardous liquid produced in landfills. Inadequate disposal methods of municipal solid waste into the dump yards results in pollution of soil and groundwater systems. Lateritic soils constitute an important group of soils in the plain districts of Brahmaputra river basin of Assam, India. The study area is situated in the southern bank of the mighty river Brahmaputra (Latitude 26°45'21"N, Longitude 94°12'34"E) has extensive lateritic formations. The soils are considered to be a good foundation material. Due to high permeability of lateritic soils open dumping of municipal solid waste may lead to environmental problems. Large areas of land are currently used for open dumping purpose. At one of the dumping yard around 150MT of municipal solid waste is being dumped without shredding and segregation. Due to heavy rainfall (2400mm annually) during monsoon leachate from such landfills flows out without any hindrance into the adjacent areas resulting in contamination of soil and groundwater. Substantial releases of leachate (due to open dumping) might have occurred during the past few years and the lateritic soil at the dump yard revealed extensive contamination. Leachate contamination may lead to significant effect on the behaviour of soils. Past work (Foreman, D.E et al 1986, Gidigasu, M.D. 1976, Gnanapragasam, N.et al 1995, Khan, A.K. et al 1994, Kirov, B. 1989) has shown that the index and engineering properties of soil contaminated with leachate lead to change due to chemical reactions between the soil mineral particles and the contaminant. In connection with any possible applications, knowledge of the behaviour of contaminated soil is required and hence the present investigation is carried out.

1.2 SCOPE OF THE PROBLEM

In the study area, lateritic soils are predominant and about 12-15 ha of load are currently used as dump yards from the past few years. Municipal solid waste is being dumped on such land without shredding and segregation. Lateritic soil at the disposal area revealed extensive contamination due to leachate. With such dumping activity in process, the geotechnical engineers are also concerned with the effect of leachate contamination on the properties of the soil. The present investigation was carried out keeping the above points in mind.

1.3 EXPERIMENTAL INVESTIGATION

The studies of MSW samples and soil contaminated leachate have been done on the basis of the result obtained in an extensive experimental program. Representative lateritic soil samples from two sites are selected in study area to study the effect of leachate contamination on shear strength, Atterberg's limit of lateritic soil. Hence in the present investigation synthetic leachate with a chemical composition most representative of the real leachate is prepared in the laboratory.

1.3.1 Preparation of Sample

In the study area , it is very difficult to obtain real leachate from the landfills .The leachate used in the present study was simulated in the laboratory .To select a representative leachate produced in landfills ,a database is prepared from published literature (e.g. Foreman, D.E. et al 1986 , Granapragasam ,N. et al 1995; Khan A.K et al 1994). The shear strength characteristics of lateritic soils were prepared and studied at standard Proctor maximum dry density $[(\gamma_d)_{max}]$ using optimum moisture content (w_{opt}) for the soil passing through 425micron sieve.

1.4 METHODOLOGY
Municipal solid waste samples from the two sites are obtained from bore holes upto a depth of 15m. (Bore Hole-1: Cremation ground landfill, Bore Hole-2: Daily market place landfill) The soils are air dried and kept for 7 days for maturation and passed through 425 mm sieve before using the same for laboratory test.

1.4.1 Sample Preparation for Shear Strength
About 300 gm of soil samples is taken for each test and after addition of contaminants the samples are placed in air tight packets and kept for 7 days for maturing. After 7 days packets are opened and test are conducted. The shear strength characteristics of lateritic soils were prepared and studied at standard Proctor maximum dry density $[(\gamma_d)_{max}]$ using optimum moisture content (w_{opt}) as shown in Table 1

Table 1 Index and Compaction Characteristics of Lateritic Soils

Bore Hole No.	G_s	Atterberg's limit			Grain size distribution				Compaction characterestics	
		w_L (%)	w_P (%)	I_P (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	$(w)_{opt}$ (%)	$(\gamma_d)_{max}$ (kN/m³)
1	2.62	48	28	20	2	62	22	12	16.3	14.6
2	2.67	42	25	17	6	66	20	8	19.2	15.4

G_s- Specific gravity of soil solids; w_L- Liquid limit; w_P- Plastic limit; I_P- Plasticity index; $(w)_{opt}$- Optimum moisture content; $(\gamma_d)_{max}$- maximum dry density.

1.4.2 Atterberg's limit
The Atterberg's limit of soil were determined using the standard liquid limit apparatus as per Indian Standard procedure.

1.5 RESULTS AND DISCUSSION
Effects of the municipal solid wastes (MSW) samples and leachate contaminated soil samples on the shear strength and other properties of lateritic soil in subsequent sections.

1.5.1 Effects of leachate on Atterberg's limit
Contaminants change the properties of their host soils Fig 1 illustrates the variation of liquid limit (w_L) of soil with increase concentration of leachate added. It is observed from Fig 1 that the leachate has significant effect on the liquid limit of the soil. The liquid limit of the soil increases with increase in concentration of leachate added. This can be attributed to leachate characteristics (Khan et al, 1994).

Mineralogical analyses of lateritic soil revealed the presence of kaolinite mineral in addition montmorillonite, quartz and calcite. The liquid limit behaviour of a montmorillonite soil is controlled essentially by diffuse double layer forces and that of kaolinitic soil by shearing resistance at particle level. In the case of lateritic soils, because of its low cation exchange capacity, the effects due to changes in diffuse double layer are negligible. However the increase in liquid limit (w_L) of the lateritic soil are mainly due to increase in clay content of the lateritic soil. As shown in Fig 1 the liquid limit of the soil has increased from 48% to 58% (when leachate concentration increased from 0 to 1 Normality) for Bore hole-1 sample.

Similar trend was observed with regard to plasticity index (I_P) of the soil. As illustrated in Table 2, the plasticity index I_P of the soil increases with the increase in leachate concentration. Fig 2 shows that the plasticity index of the soil has increased from 20% to 26% for Bore Hole-1 sample.

Table 2 Liquid Limit and Plasticity Index of Lateritic Soil after Contamination with Leachate

Bore Hole No.	Parameters	Soil mixed with leachate with varying concentration (N)			
		0	0.25	0.50	1.0
1	w_L (%)	48	50	53	58
	I_P (%)	20	21	23	26
	Clay (%)	12	12.2	12.5	13.1
2	w_L (%)	42	43	45	47
	I_P (%)	17	19	20	23
	Clay (%)	8	8.3	8.7	9.2

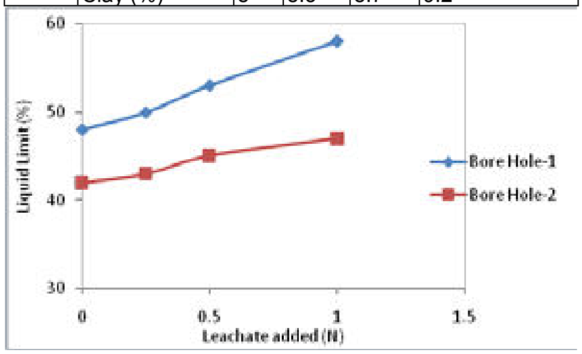

Fig 1 Variation of Liquid Limit with Leachate added (N)

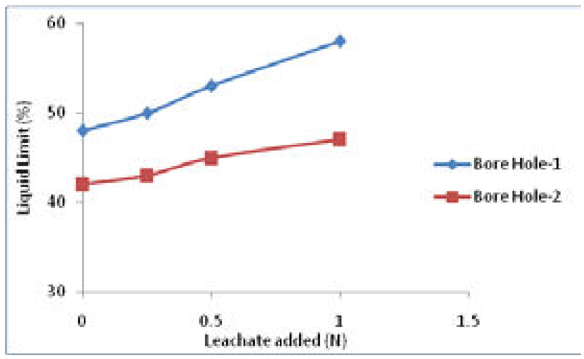

Fig 2 Variation of Plasticity Index with Leachate added (N)

1.5.2 Effects of leachate on Shear Strength Properties
Shear strength measurements are conducted on lateritic soil samples contaminated with leachate with varying concentrations (0 N, 0.25 N, 0.5 N, and 1.0 N). All samples are prepared at standard Proctor maximum dry density $(\gamma_d)_{max}$. Table 1.3 shows the shear strength parameters for leachate contaminated soil. There is slight increase in cohesion and the decrease in friction angle as a result of leachate contamination for samples tested at the Proctor density. The increase in clay content of lateritic soil after interaction with the leachate has increased the cohesion and hence the friction angle decreases. The experimental results are plotted in Fig 3 and Fig 4.

Table 3 Shear Strength Parameters of Lateritic Soil after Contamination with Leachate

Bore Hole No.	Shear Parameters	Soil mixed with leachate with varying concentration (N)			
		0	0.25	0.50	1.0
1	c' (kPa)	18.5	19.1	19.6	20.3
	ϕ' (degrees)	31	30	28	26
2	c' (kPa)	19	19.3	19.8	21
	ϕ' (degrees)	30	29	27	25

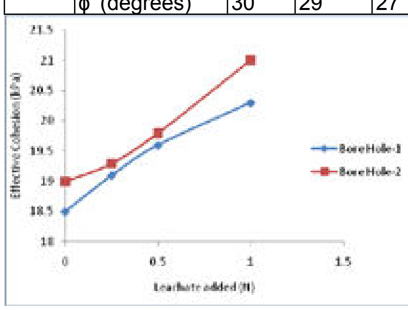

Fig 3 Variation of Effective Cohesion with Leachate added (N)

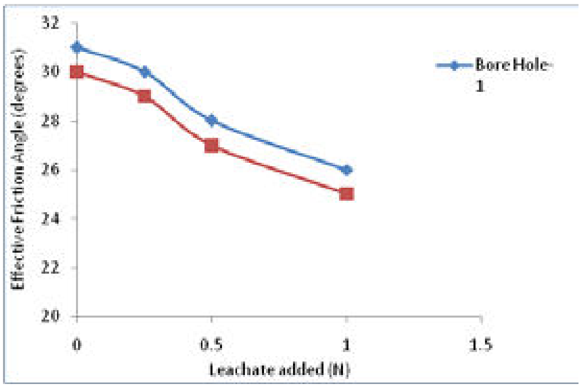

Fig 4 Variation of Effective Friction Angle with Leachate added (N)

1.6 CONCLUSIONS

An extensive laboratory testing program is carried out to study the effect of leachate contamination on the Atterberg's limit and shear strength parameters of lateritic soils. The following conclusions are made based on the test results:

The leachate can alter the Attterberg limit of lateritic soils. All the leachate contaminated lateritic soil samples showed an increase in liquid limit and plasticity index values. The increase in liquid limit (w_L) and plasticity index (I_P) of the lateritic soil is attributed due to change in nature of pore fluid which is shown by increase in clay content of the soil. The disintegration of clay particles from the aggregates due to acidic or alkaline leachate in the pore media tends to increase in the specific surface area of soil which leads to high adsorption of water that changes the limit values.

Shear strength parameters of lateritic soils are affected by leachate contamination. For samples tested at the Proctor density, effective cohesion (c') increases and effective friction angle (ϕ') decreases due to increase in leachate concentration. The increase in clay content of lateritic soil after interaction with the leachate has increased the cohesion and hence the friction angle decreases.

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