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Investigating the Consolidation and Shearing Behavior of Clay Contaminated with Municipal Solid Waste Leachate

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ABSTRACT: In this research, the effect of leachate on the shear strength parameters of fine soils was investigated in the laboratory conducting 14 consolidation, 42 large-scale direct shear test and SEM photography. Consolidation and shear tests conducted on specimens contaminated with different percentages of leachate ranging from 5% to 20% in short-term after 96 hours of contamination and long-term after 180 days of contamination. The results of these tests indicated that leachate contamination reduced the shear strength and compression index of clay. The peak shear strength of contaminated specimens achieved in lower deformations when compared to intact specimens. In the soil of CH and CL, with the increasing the leachate content up to 20% reduced the shear strength by about 30% in the short-term and by about 40% in the Long-term compared to intact specimens. In the soil of CH, with the increasing the leachate content up to 20%, reduced the compression index of soil by about 45% in compared to intact specimens. Results of this study showed that with the increasing the leachate content up to 20%, the peak shear strength of contaminated specimens achieved in lower deformations (36% lower deformations for CH and 32% lower deformations for CL) when compared to intact specimens.

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1- Introduction

Landfills are the most convenient way of disposal of municipal solid wastes. Rainfall permeates trough landfills and produces leachate that contaminates the environment [1-5]. Most important consequences of the burial method of waste disposal practice are the chemical, ecological and mechanical effects of the produced leachate on the surrounding soil layers. Leachate contains several chemicals that permeate trough soil layer by porous fluid. These substances change the hydraulic, consolidation and shearing behavior of soils [6]. Landfills could be isolated by low permeable soils such as clay to prevent further diffusion of landfill leachate [7]. Therefore; the effect of the leachate on the mechanical properties of the clay is an important in the design and construction of modern landfills [8, 9]. In this paper the effect of the leachate on the consolidation and the shear strength parameters of two clays with different liquid limits have been investigated in laboratory.

2- Materials and Method

Two types of clay soils CL and CH used in this study were collected from Golsar district in Rasht city and Rasht-Qazvin road (km 35) respectively. The leachate used in this study was also collected from main landfill of Rasht city. Basic characteristics of the clays used in this experiment are presented in Table 1. All of tests conducted according to ASTM standards.

Table 1. Basic parameters of clays

Parameter	CL	CH
Opt. Water Content	23	20
Max. Dry Density (gr/cm^3)	1.52	1.58
LL(%)	40	52.5
PL(%)	25	25
PI(%)	16	27.5
Gs	2.64	2.67

Atomic absorption spectrograph (AAS) tests conducted on the leachate to determine its chemical components and their concentrations. The chemical components of the leached was according to Table 2.

Specimens for large scale direct shear and consolidation tests paper in the laboratory using oven dried samples in 110o C for 24 hrs. The dry soil specimens mixed with 5%, 10% and 20% leachate. All specimens cured for 180 days in room temperature to accomplish the chemical reactions between the soil and leachate. This curing time was determined based on several trials until the leachate contaminated soil parameters achieved a constant limit [10].

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Table 2. Leachate components and their concentrations

	Component	Concentration (mg/li)
Nitrogen	NH3-N	1140-2591
Ion	Cl^-	5630-6340
	SO_4^{4-}	142-652
Metals	Mg	363/8-640
	Ca	97-787/5
Heavy Metals	Mn	0.11-5/6
	Fe	14.2-44
	Cr	0.02-0.78
	Ni	0.32-0.45
	Cu	0.02-0.13
	Zn	0.38-1.06
	Cd	0.01
	Pb	0.04

3-Results and Discussion

The results of Atterberg limits of virgin and leachate contaminate clays are presented in Table 3.

Table 3. Basic parameters of clays

Leachate Content	0	5%	10%	20%
LL(CH)	52.5	46	40.5	37
PL(CH)	25	25	24.8	24.7
PI(CH)	27.5	21	15.7	12.3
LL(CL)	40	37	34	27
PL(CL)	25	24.7	25	25
PI(CL)	15	12.3	9	2

As can be seen in Table 3, the liquid limit of all specimen reduced as the leachate content increased. Also, the plastic limits of all samples were remained unchanged. The effect of the leachate on the Atterberg limits of different soils would be different [10]. Changes of the compression indexes (Cc) of leachate contaminated CH and CL clays vs. leachate content after 90 and 180 days are shown in Figures 2 and 3 respectively.

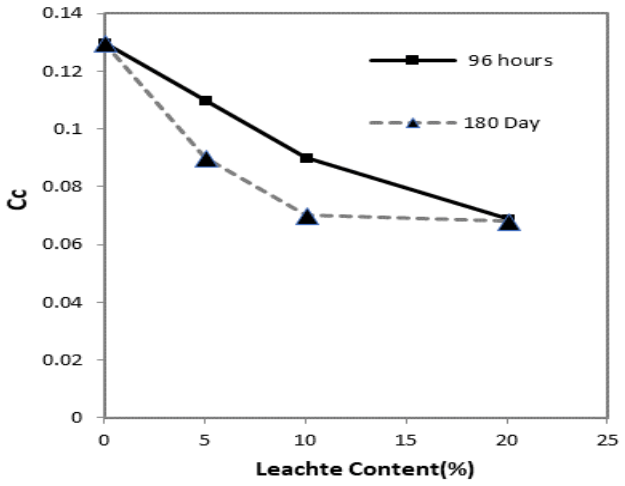

Figure 1. Effect of leachate content on compression index of CH clay

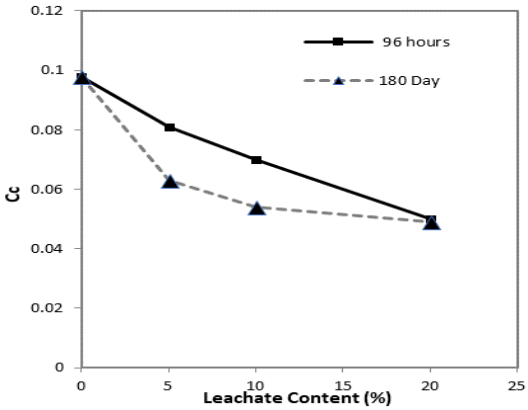

Figure 2. Effect of leachate content on compression index of CL clay

It can be seen in Figures 1 and 2 that the leachate contamination reduced the compression index of both CL and CH clays. Also, the effect of the lower contents of leachates in long term tests are close to the effects of higher leachate contents in short term tests.

Table 4. Shear strength parameters of contaminated clays

Soil	Leachate (%)	Curing time	C (kPa)	ϕ^o
CH	0		40	18
CH	5	96H	44	17
CH	10	96H	45	13
CH	20	96H	46	9
CH	5	180D	45	15
CH	10	180D	47	10
CH	20	180D	48	5
CL	0		48	15
CL	5	96H	51	14
CL	10	96H	52	10
CL	20	96H	53	6
CL	5	96H	52	12
CL	10	96H	52	7
CL	20	96H	53	3

Based on the results of direct shear tests conducted on leachate contaminated clays, it can be concluded that the leachate contamination reduced the internal friction angle of clay while the changes of the cohesion were very small.

4- Conclusions

In this paper the effect of the leachate on the compression and shear strength of the clay were investigated in the laboratory. The results of this study indicated that the leachate contamination reduces the liquid limit of both CL and CH clay but its effect on both soils are not the same. Also, the leachate contamination reduced the compression index and initial void ratio of contaminated soil. The results of direct shear tests indicated that the internal friction angle of leachate contaminated soil was also decreased as the leachate content of contaminated soil increased. Although the cohesion of contaminated specimens increased slightly, however it was concluded that it was not resulted from chemical reactions between clays and the leachate.

References

Foreman, D.E., Daniel D.E., 1986 "Permeation of compacted clay with organic chemicals". Journal of Geotechnical Engineering, ASCE Vol.112(7), pp. 669-681.

Gidigasu, M.D., 1976 "Laterite Soil Engineering Pedogenesis and Engineering Principles". Elsevier Scientific Pub. Amsterdam.

[3] Gnanapragasam, N., Lewis, B.G., Finno, R.J., 1995 "Microstructural changes in sand-bentonite soils when exposed to aniline". Journal of Geotechnical Engineering, ASCE, Vol. 121(7), pp. 119-125.

Kamon, M., Ying, C., Katsumi, T., 1996 "Effect of acid rain on lime and cement stabilized soils." Japanese Geotechnical Society, Vol. 36(4), pp. 91-96.

Khan, A.K, Pise, P.J., 1994 "Effect of liquid wastes on the physico chemical properties of lateritic soils". Proceedings of Indian Geotechnical Conference, Warangal, pp.189-194,

Dutta, J., Mishra., A.K., 2016 " Consolidation behaviour of bentonites in the presence of salt solutions". Elsiver. Applied Clay Science. 120. Volume 3, Issue 7, pp 61–69.

Sitaram Nayak., B. M. Sunil., S. Shrihari P. V., Sivapullaiah., 2010 " Interactions Between Soils and Laboratory Simulated Electrolyte Solution". Springer. Geotech Geol Eng. 28, pp:899–906.

Sunil, B.M., Shrihari, S., Nayak, S., 2009 "Shear strength characteristics and chemical characteristics of Leachate contaminated lateritic soils". A Journal Engineering Geology, Vol. 106, pp 20 – 25.

Pming, M., Hussain, M., Nyodu, M., Shivan, D., 2016 " A Study on the Chemical Properties of Leachate its Effect on the Geotechnical Properties of Soil". IJETSR. International Journal of Engineering Technology Science and Research. Volume 3, Issue 7.

Ouria, A. and Farsijani, A., 2017 " The effect of waste leachate on the mechanical behavior of high plasticity and low plasticity clay soils". AMIRKABIR Journal of Civil Engineering. DOI: "10.22060/CEEJ.2017.13361.5392". 2017(in Persian)

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