Investigation of Gasoil Contamination Effect on the Erodibility of Soils Rich- lime Around the Hamedan Oil Storage using Rainfall Simulator

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Extended Abstract

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Introduction

In regard to consumptions of oil materials by human, soil contamination causes worriness in environment and geotechnics areas in previous years, such that studying of soils lead to soil refine, soil bearing capacity and soil changing by infiltration of contamination. The rates of problems on environment are different and it depends on soil types and its structure, organic materials values, soil permeability, climate and type of contamination. In viewpoint of geotechnics, many investigations have been done on various contaminated soils that their result leads to optimum application of those as road construction and decrease of costs. In this research, with adding of different percentages of gasoil into the soil, engineering properties of contaminated soils were investigated and its effect on the erodibility of soils was studied. Regarding to the Hamedan oil storages complex extension and lateral installations, the study of contaminated soils are essential. Also, because the location of that complex is at urban area, the environmental risk of leaking of oil materials is available. Thus, the goal of this research is to investigate the erodibility of contaminated soils at the studied area.

Material and methods

Hamedan oil storages complex is located about 17.7 km far from Hamedan city. In order to study engineering geological properties and erodibility of three layers of soils in studied area, the soil samplings were done from three soil layers. Based on the field and laboratory results, all of three soil layers were classified into SM class and had too much lime

(Table 1). Testing program is divided into engineering geological tests and erodibility tests. All of the engineering geological tests on the uncontaminated and contaminated soils were undertaken according to ASTM (2000) (Table 2). In order to prepare the contaminated soils and to determine the maximum absorbable gasoil, the soil samples were contaminated by gasoil and some standard compaction tests were undertaken on the soils. According to the test results, upper and lower layers were saturated by 19% of gasoil and middle layer was saturated by 15% of gasoil. After determination of gasoil saturations percentages for studied soil layers, the 7, 13 and 19 percentages of gasoil were added into the upper and lower layers and the 5, 10 and 15 percentages of gasoil were added into the middle layer. Thus, for engineering geological tests, 9 samples of contaminated soils were prepared.

Table 1. Soil properties of studied area

Layer	Sample	LL%	PL%	PI%	Soil type	Lime percentage
Upper	L1	49.64	40.65	8.99	SM	85.15
Middle	L2	47.61	32.12	15.49	SM	62.16
Lower	L3	42.60	27.14	15.46	SM	88.72

Table 2. Engineering geological tests according to ASTM (2000)

Test type	Standard No.
Soil classification	ASTM-D422 (2000)
Atterberg limits	ASTM-D4318-87 (2000)
Standard Compaction	ASTM-D698 (2000)
Direct shear	ASTM-D3080 (2000)
Uniaxial Compressive Strength	ASTM-D2166-87 (2000)

To prepare the sample for direct shear test, a mould with dimension of 10 cm *10 cm *2 cm was used. Then, the prepared sample was set inside the shear box and vertical stress was applied. All of direct shear tests were done in unconsolidated-undrained condition (UU), in maximum dry unit weight (γ_{dmax}) and in optimum water content (ω_{opt})of soil samples.

All of the soil samples for uniaxial compressive strength tests were prepared in maximum dry unit weight and optimum water content. To prepare the soil samples, a split tube mould with 5*10 cm of dimensions was used. Based on that test, the soil samples are set under axial load and failure occurred at the end of the test.

To investigate the effect of gasoil on soil erodibility, first the erodibility tests by using rainfall simulator were done on uncontaminated soils and then, on contaminated soil with different percentages of gasoil. All of soil samples for erodibility test were prepared into the pans with 30*30*15 cm of dimensions and in maximum dry unit weight and optimum water content. The thickness of soil samples were 5 cm and the gravelly drainage layers were 10 cm. The rainfall intensity was equal to rainfall intensity of sampling area (29 mm/hours) and the steepness of soil samples were equals to sampling area steepness (10 to 40 degrees). After catching of runoff and drained water, the eroded soils were weighted and the weight loss of soil samples was calculated.

Results and discussion

All of the engineering geological tests results are shown in Table 3. With increasing of the gasoil percentages, dry maximum unit weights of all three layers have decrease trends while the optimum water contents have increase trends. Surrounding of the soil grains by gasoil and water causes the easy sliding of grains and more compaction. The Atterberg test results shows that liquid and plasticity limits of soil had increase trend with increasing the gasoil. In the middle layer its trend is more than the others. Because the viscosity of gasoil is more than the water viscosity, the adhesion of contaminated soil would be more than the uncontaminated soil and then, the liquid and plasticity limits of contaminated soils are more than the others. The uniaxial compressive strength results show that the undrained strength of contaminated soils would be decrease with increasing the gasoil content. This behavior is the result of sliding of the contaminated soil grains on each other.

The results of erodibility tests results are shown in Table 4. The erodibility would be increase with increasing the gasoil percentages. Also, it would be increase with steepness dips degrees. In compare to the uncontaminated soils, the maximum weight loss of the contaminated soil is 608.3 $kg/m^2.hr$ in 15% of gasoil and 40 degrees of steepness in L2 layer.

The minimum weight loss of the contaminated soil is 13.33 kg/m^2.hr in 0% of gasoil and 10 degrees of steepness in L3 layer. Thus, the assessment of gasoil effect on erodibility of soils is very important.

Table 3. Results of the engineering geological tests on the uncontaminated and contaminated soil samples

Layers	Gasoil percentage	Liquid limit (%)	Plasticity limit (%)	Plasticity Index (%)	Maximum dry unit weight (g/cm^3)	Optimum water content (%)	Internal friction angle (ϕ)	Cohesion (kPa)	Uniaxial compressive strength (kPa)
L1	0%	49.64	40.65	8.99	1.65	22	4.6	7.4	18.4
	7%	54	40.13	13.87	1.87	10.5	4.04	6.6	8.7
	13%	55.67	43.71	11.95	1.88	8.5	3.26	3.7	7.8
	19%	55	40.65	14.34	1.96	3	2.3	2.75	3.5
L2	0%	47.61	32.12	15.49	1.87	14	6.97	6	9.6
	5%	64	40.39	23.61	2.08	9	5.73	5.5	7
	10%	66	46.63	19.37	2.11	6	5.15	4	6.1
	15%	68	49.09	18.91	2.14	3.5	4	2	1.25
L3	0%	42.6	27.14	15.46	1.62	22.3	2.6	10.7	22.6
	7%	56	39.27	16.72	1.92	9.5	2.41	8.5	10.5
	13%	57.18	41.66	15.51	2.01	6	2.17	7/3	7.8
	19%	63	42	20.99	2.03	3	1.45	6.9	4.4

Table 4. Results of the uncontaminated and contaminated soils in different steepness*

Layer	Gasoil percentage	Dip of 10◦	Dip of 20◦	Dip of 30◦	Dip of 40◦
L1	0%	56.4	70.4	73.2	111.06
	7%	149.6	178.8	248.4	202.53
	13%	166.53	227.2	241.6	278.93
	19%	227.86	256.66	419.86	334.66
L2	0%	30.8	102.53	156.53	317.73
	5%	58.66	142.66	151.2	324.8
	10%	74.93	168.66	244.53	365.73
	15%	105.73	283.73	359.86	608.13
L3	0%	13.33	75.06	79.46	86.26
	7%	55.2	98.53	78.13	81.06
	13%	124.13	176.8	145.73	140.06
	19%	196.4	279.46	200.93	210

Conclusion

1. According to the grain size analysis test results, all of three layers of soils around the Hamedan oil storage are SM with too much lime.
2. With increasing the gasoil, liquid and plasticity limits of three soil layers had increase trend. its trend in the middle layer is more than the others.

3. According to the erodibility results of contaminated soils, the weight loss of middle layer was more than the other layers because of the middle soil layer had lower percentages of lime.
4. The gasoil causes decrease of soil strength and increase of weight losing. Thus, the uniaxial compressive strength and weight losing have reverse correlation.
5. With increasing of the contamination, the cohesion and internal friction angle of soils would be decrease and then, the erodibility would be increase.
6. Maximum of erosion of contaminated soils was in 15 and 19 percentages of gasoil and it was three times more than that of uncontaminated soils.
7. The critical steepness of uncontaminated soil layers was 40 degrees for all three layers, but it was different for contaminated soils,
8. Regarding to the location of Hamedan oil storages, the environmental risk of oil leakages and erodibility of contaminated soils are certain.

Keywords: Soil contamination, engineering geological properties of soil, rainfall simulator, erodibility, oil storage, Hamedan

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