Numerical and Analytical Evaluation of Crude Oil Contamination Effect on Strip Foundation's Bearing Capacity

Engineering

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ABSTRACT

In the worldwide some soils are contaminated to crude oil. For example due to seepage from oil transport pipes, soil of refineries were polluted. Because of sensivity of structures in refineries, bearing capacity changes have significant importance. In this study by using 3 types soil's shear strength parameters which made by other researchers by the means of experiment, effect of pollution amount on strip foundations bearing capacity were investigated by numerical and analytical pieces software. Eventually based on ordinary least square method (OLS) empirical equations prepared to calculate reduction in bearing capacity.

INTRODUCTION

Increasing use of oil to supply industry, increase soil contamination with it too. Because of soil pollution possibility amount of it in refineries are more than other places and also structures in these places have high sensivity, evaluation of of oil contaminations on bearing capacity of strip foundation and compute reduction due to contamination have material importance.

There is a large volume of published studies describing this fact that is shear strength parameters of soils were changed by hydrocarbon pollution (e.g. Khamehchian and et.al 2007, Ashraf K. Nazir 2012, Rajaei and et.al 2012 and etc.). In this paper by measured parameters by Khamehchian and his collogues, bearing capacity of strip foundation were determined and effects of contamination content and embedment depth were studied.

Material Properties and Methodology

In this research by measured parameters by Khamehchian and his coworkers bearing capacity of strip foundation by 2 meter width placed on low activity clay (CL), poorly graded sand (SP) and silty sand (SM) with different embedment depth calculate by using 3 methods and effect of contamination content and embedment depth were studied. In Khamehchian research, soils by 0,4,8,12 and 16 percent of dry weight are contaminated with crude oil. Embedment depth over base width ratio which consider in this paper are equal to 0, 0.25, 0.5 and 1. Method which used to determine bearing capacity are Hansen classic method, FIDES software which work based on DIN standard and finite element software PLAXIS. Thank to insignificant difference among results, to study effect of contamination, average of 3 methods results was used. In Plaxis software, Mohr-Columb Elastic-plastic model was used. Specific weight, internal friction angle and cohesion with different contamination percentage are prepared in tables 1 to 3. Table 4 shows geometric parameters of foundation.

TABLE – 1
CL Soil properties

Oil Content %	0	4	8	12	16
[kN/m^3]	18.64	18.47	18.28	18	18.09
[degree]	26.3	27.4	28	28.6	34.2
C [kN/m^2]	75	25.9	19.3	17.6	16.3

TABLE – 2
SM Soil properties

Oil Content %	0	4	8	12	16
[kN/m^3]	19	18.67	18.38	18.4	18.19
[degree]	33	32.9	32	26.2	26.2
C [kN/m^2]	24.7	17.9	20.3	18.9	30.9

TABLE – 3
SP Soil properties

Oil Content %	0	4	8	12	16
[kN/m3]	18.28	18.3	18.19	18.2	18.09
[degree]	34.5	32.2	31.8	29.3	27.6
C [kN/m2]	1	3.3	7.6	7	6

TABLE – 4
Geometric Parameters Of strip Foundation

Method / Software	B [m]	L [m]	D/B	[m]
Hansen Method	2	20	0	0
			0.25	0.5
			0.5	1
			0.75	1.5
			1	2
FIDES	2	infinity	0	0
			0.25	0.5
			0.5	1
			0.75	1.5
			1	2
PLAXIS	2	infinity	0	0
			0.25	0.5
			0.5	1
			0.75	1.5
			1	2

Because of minor effect of module of elasticity, poison ratio and dilatation angle on bearing capacity, all of them consider constant value in all models and their value showed in table 5.

TABLE – 5
Constant Values of Soil's Properties

E [kN/m²]		
15000	0.333	20

Verification

To verify because of near results of 3 methods, Plaxis results take as an example. Software results compared with an experiment data obtained from big scale foundation loading test were published by Briaud et.al in 1997.

As figure 1 shows, numerical results have good correlation with experimental data. Also minor difference between Hansen

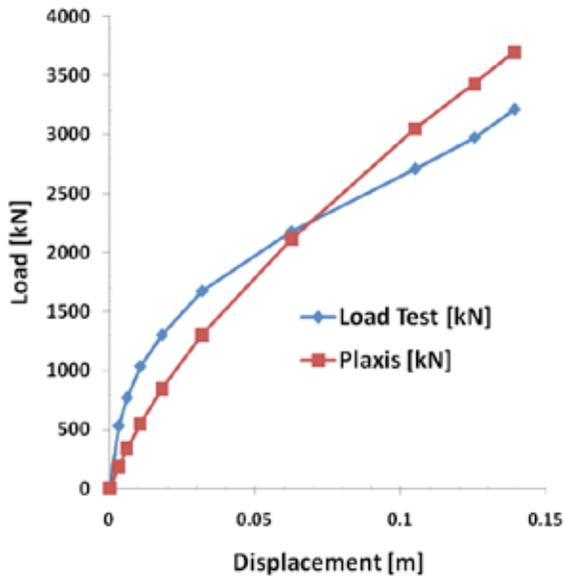Method results and software prove accuracy of numerical results.

Figure 1: comparison of numerical results and experimental data

Sensivity analysis in Plaxis
To obtain optimum model which has minimum effect on results, sensivity analysis must done. For this purpose in each session, all parameters were fixed and by taking various values for a certain parameter, its effect on results is studied. At last, by drawing result changes based on specific parameter changes diagram and analyze this graph, effect of specific parameter on results studied and based on general results optimum model obtained.

Numerical and analytical analysis
First of all the method of determine ultimate point on load-displacement graph must be taken. The point which take in this study where diagram reach the horizontal asymptote. This method was used by other researchers such as Alimadan. Lavasany and Ghazavi (2012).

To investigate contamination effect, reduction factor (f) defined as below.

$$f = \frac{q_{u_{oil-contaminated\ soil}}}{q_{u_{non-contaminated\ soil}}} \quad (1)$$

Results
Reduction factor for all embedment depth in different oil contents in CL soils is shown in figure 2.
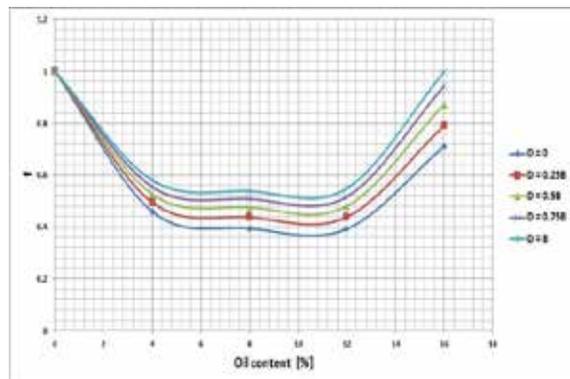

Figure 2: Reduction factor- oil content graph in CL

By increasing oil content in first 4 percent, bearing capacity reduction trend increase as it can be inferred from graph and this reduction factor remain almost constant up to 12 percent oil content and slash remarkably after 12 percent oil content. Also as figure 2 demonstrate in CL soils by bouncing embedment depth reduction factor in contaminated soil decrease.

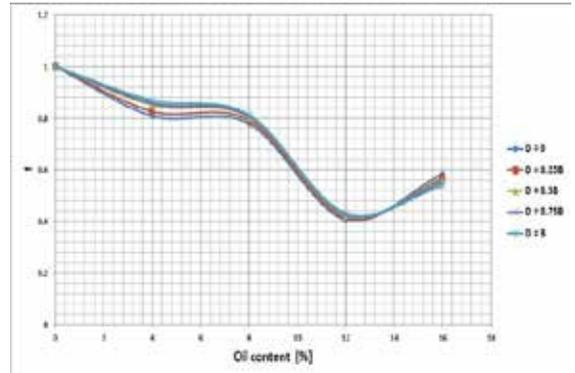Figure 3 shows reduction factor changes with same conditions for SM soils.

Figure 3: Reduction factor- oil content graph in SM

It can be conclude from figure 3 that oil content increasing up to 8 percent has not significant effect on bearing capacity but between 8 to 12 percent oil content bearing capacity reduce dramatically and this reduction reach the highest point at 12 percent. In oil content percentage more than 12 reduction risen. As well as based on figure 3, embedment depth has minor effect on bearing capacity in contaminated silty sand.

Reduction factor for poorly graded sand is prepared in figure 4. It can be seen that behavior of SP is similar to SM up to 4 percent oil content and between 4 and 16 percent oil content reduction factor has smooth increase at first which followed by downward trend.
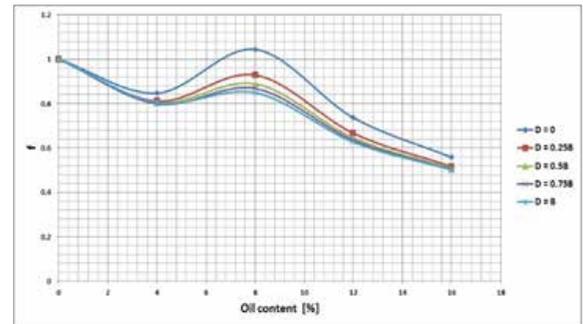

Figure 3: Reduction factor- oil content graph in SP

Compute reduction factor
By using OLS method equations for reduction factor were obtained with appropriate correlation coefficient. They illustrated in equations 2 to 4 for each soil type.

For CL Soil:
$$f = 0.24 Oil\ content + 0.12 D_f \quad (2)$$

For SM soil:
$$f = -2.7 Oil\ content + 0.04 D_f \quad (3)$$

For SP soil
$$f = -2.7 Oil\ content - 0.037 D_f \quad (4)$$

In this equations f is reduction factor which defined in equation 1, oil content is crude oil weight over soil dry weight in percent and D_f is embedment depth.

Conclusion

In this session significant conclusions are listed in following.

- In most cases crude oil contamination cause reduction in bearing capacity. But increasing was seen in some cases such as poorly graded sand.
- Bearing capacity reduction depends on embedment depth, soil type and contamination content.
- Based on soil type oil content range can divided into some part which in each part bearing capacity reduction is linear.
- In poorly graded sand, bearing capacity rise between 6 to 9 percent oil content.
- By multiplying reduction factor obtained from equations 2 to 4 to bearing capacity of same foundation placed on non-contaminated soil, bearing capacity of foundation in contaminated soil can derived.

REFERENCE

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