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STUDY ON STRENGTH AND SETTLEMENT CHARACTERISTICS OF OIL CONTAMINATED SOIL USING PHOSPHOGYPSUM

Dr.V.S Pradeepan, Principal, I.E.S College of engineering, Thrissur, Dr Pradeepan IES@gmail.com

V.P Reethi, Assistant Professor, IES College of Engineering Thrissur,reethi126@gmail.com

Namitha.N, M-Tech student, IES College of Engineering Thrissur, namithan190@gmail.com

ABSTRACT: Oil spills and oil leakage from the storage tanks is one of the main problems facing the oil producing countries of the world. The effect of theses leaks and spills create problems to the environment. It pollutes subsurface water, changes the behavior of soil and also its engineering properties and loss in strength of soil, which leads to differential settlement and cracks in existing foundation of structures. This paper presents the study of strength and settlement characteristics of oil contaminated soil with phosphogypsum. The soil is taken from near BPCL, India and the soil was contaminated by adding varying percentage of diesel oil. Compaction, unconfined compression strength test and plate load tests were conducted on the soil samples. The optimum moisture content, maximum dry unit weight, unconfined compression strength and settlement characteristics of the soil decreases with increase in diesel oil content. From the above test results it is obtained that 16% of diesel contaminated soil gives worst strength, so stabilized this oil contaminated soil with phosphogypsum in different percentage. Strength and settlement characteristics of oil contaminated soil improved maximum at 9% of phosphogypsum.

INTRODUCTION

Oil contamination in soil may happen in many ways like oil spills during transportation on the land or oil drilling, leakage from storage tanks, oil tanker accidents etc.This contamination affects the environment very badly.

Oil contamination is not only harmful for subsurface water aquifers but is also a detriment to the buildings and structures on it.Any change in the engineering properties and behaviour of the soil strata may lead to a loss in the bearing capacity and an increase in the total or differential settlements of the foundation systems of structure. There have been a few methods to improve the oil contaminated areas. Thus in order to minimize potential environmental impact of this contamination, it must undergo an efficient chemical treatment or stabilization. In this paper present a study on strength and settlement characteristics oil contaminated soil with phosphogypsum (PG).It is a waste by-product produced during the production of phosphoric acid

LITERATURE REVIEW

Various researchers have studied on oil contamination and major findings from literatures are Oil contamination adversely affects geotechnical properties of soil and also harmful to environment, It decreases the strength of soil. Presence of oil contaminated layer under footing results decrease in bearing capacity ratio (BCR) and increases the settlement. Oil contaminated soil cannot be used without conducting stabilization or remediation techniques

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MATERIALS USED

Soil

Soil used in this study is a grey colored clayey soil which was collected from a borrow pit of 1 m depth near BPCL, India

Oil

Oil used in this study is diesel purchased from Bharath petroleum dealer. Diesel oil used has light yellow colour, specific gravity at 40 degree centigrade is <.835 and kinematic viscosity at 50 degree centigrade is 73.5

Phosphogypsum

Phosphogypsum used in this study is purchased from FACT Kochi. Phosphogypsum is light yellow color

Properties of materials

Table 1 Chemical composition of phosphogypsum

Description	Value(%)
$CaSO_4$	95.32
TOTAL P_2O_5	1.04
Water soluble	.203
P_2O_5	.32
F	.028
Fe_2O_3	.26
Na_2O	.0016
K_2O	2.82
Insoluble solvents	

Basic properties of uncontaminated soil

Results of index properties, compaction and strength test on the uncontaminated soil are presented in Table 1. According to the Unified soil classification (USC) system it is classified

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as Sandy lean clay (CL), of low plasticity clay. Figure (1) graphically illustrates its particle size distribution

Table 1 : Properties of the uncontaminated soil

Properties	Value
Sand (0.075-4.75mm)	49.14%
Silt and Clay (<0.075mm)	50.74%
Unified soil classification system	CL-Sandy clay
Colour	Grey
Natural moisture content	40%
Organic content	3.8%
Specific gravity	2.7
Liquid limit	41%
Plastic limit	20%
Plasticity index	21%
Shrinkage limit	13%
Maximum dry unit weight	18.5(kN/m^3)
Optimum moisture content	20.9 %
Unconfined compressive strength	129(kN/m^2)

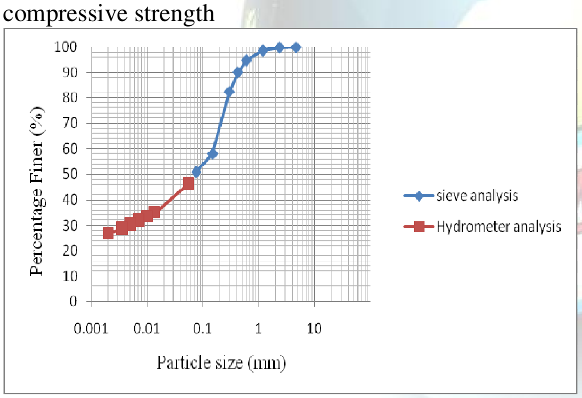

Figure 1. Particle size distribution of uncontaminated soil

Methodology

Samples were collected in jute bags, air dried and transported to the laboratory. It is then powdered and sieved through a 4.75mm IS sieve and divided soil samples in to 5 portions. Diesel was added to each of the portions at 0%, 4%, 8%, 12% and 16% by dry weight of soil sample. Soil- diesel oil mixture were thoroughly mixed and stored in containers for 48 hours for allowing possible reaction. After that compaction, unconfined compression test and plateload tests was conducted.There is some limitation for addition of more diesel oil to the soil sample. Using more than 16 percentage of diesel oil the soil tests are become difficult to conduct due to the looseness of the particles and draining of excess oil during compaction test from the sample. From this above tests it is obtained that particular % of diesel contaminated soil gives worst strength, so stabilized the oil contaminated soil in that % with varying % of phosphogypsum and conducted compaction, UCS and plateload test.

LABORATORY MODEL TESTS

Test Setup For Conducting Plate Load Test

The experimental model tests were conducted in a test tank that had dimensions .8m×.3m in plan and 0.6m in depth. As per provision of IS 1888-1962, the depth of the test pit should not be less than 4 times the width of the test plate, so that the failure zones are freely developed without any interference from sides. The tank was made of steel. The load was applied by means of a hydraulic jack over which proving ring is connected in order to measure the applied load. A dial gauge is provided for the measurement of corresponding settlements. The test set up is shown in Fig.2. The strip footing was made of rigid steel plate with width of 50mm, a thickness of 16mm and length equal to width of the tank.

Figure 2: Test load set up

An experimental program was carried out to study the settlement behavior of strip footing on contaminated soil in different percentage of diesel and stabilized contaminated soil with optimum % of phosphogypsum. A sand layer of 10cm thickness was formed at the bottom of the tank for allowing drainage from the clay bed above. The clay was filled in the tank based on the density and water content obtained from compaction tests. Top clay layer of 20cm height from the top of the tank is replaced with soil mixed with varying % of diesel oil during each plate load test After that conducting plate load test in oil contaminated soil with optimum % of phosphogypsum. Fig 3 shows schemating representation of test set up

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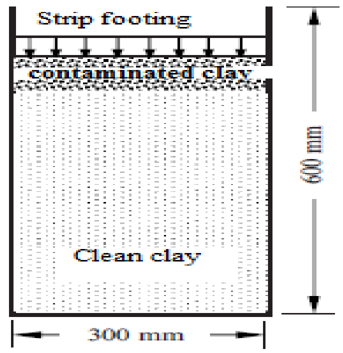

Fig 3 Schematic test set up

RESULTS AND DISSCUSSION

Compaction characteristics of diesel oil contaminated soil

Unconfined compressive strength characteristics of diesel oil contaminated soil

The results of compaction test are shown in figure 4. As diesel oil contamination in soil increases, both the optimum moisture content and maximum dry unit weight of soil decreases. The diesel oil is hydrophobic and it coats itself around individual clay particles and prevents the entry of water which interacts with clay particles, so it reduces the amount of water needed by the soil to reach it maximum dry unit weights. Therefore, optimum moisture content decreases with increasing diesel oil content. The diesel oil in the soil creates some micro structural transformation and increases inter layer expansion within clay minerals and also increase the thickness of diffused double layer. Therefore, using the same compaction effort as that used for compacting uncontaminated soil, the soil particles are less packed together and it leads decrease in dry unit weight of contaminated

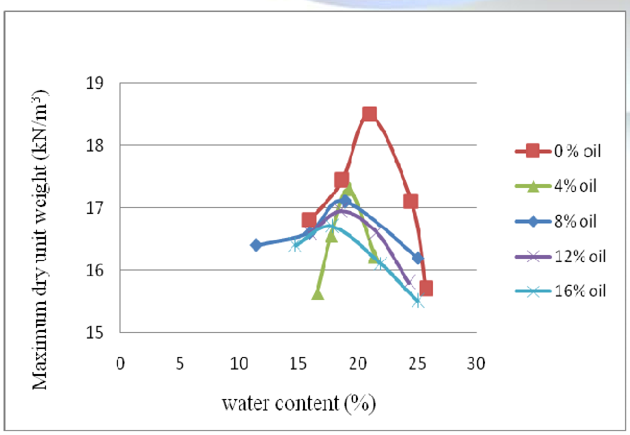

Figure: 4 Compaction curves of soil at different oil percentage

Figure 5 shows the variation of maximum dry unit weight and OMC with diesel oil content. As diesel oil contamination in soil increases, both the optimum moisture content and maximum dry unit weight of soil decreases by 14.5% and 9.7% respectively.

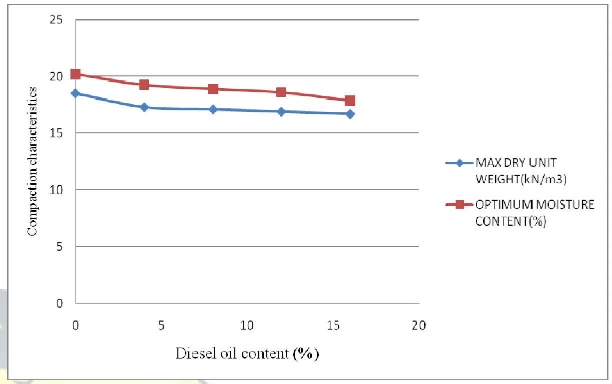

Figure 5 Variation of maximum dry unit weight and OMC with diesel oil content

Figure 6 shows the axial stress-strain curve for different % of oil content. Unconfined compressive strength (UCS) decreases drastically with the increase in diesel oil contamination in the soil. The diesel oil content leads to decrease in the soil density and looses the soil particles, so it leads to the weakness of soil and decreases the strength

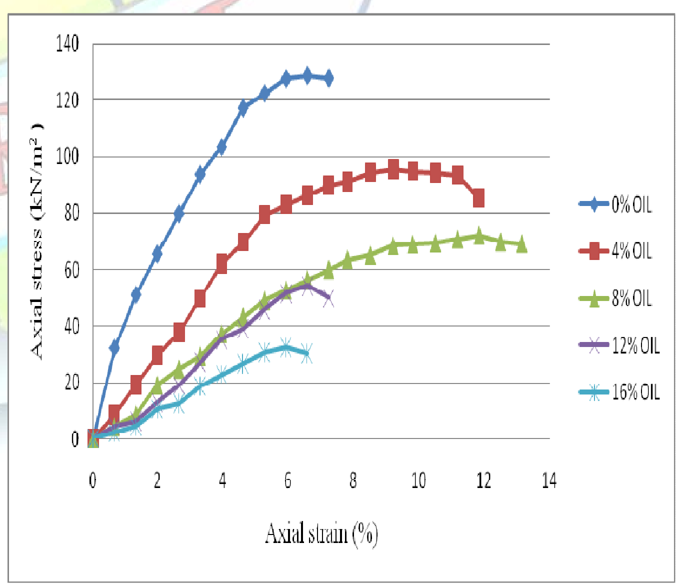

Figure 6: Variation of axial stress –strain curves of soil with different percentage of oil content

Figure 7 shows the variation of UCS of soil with oil content. Unconfined compressive strength decreases 75% with 16% increase in diesel oil

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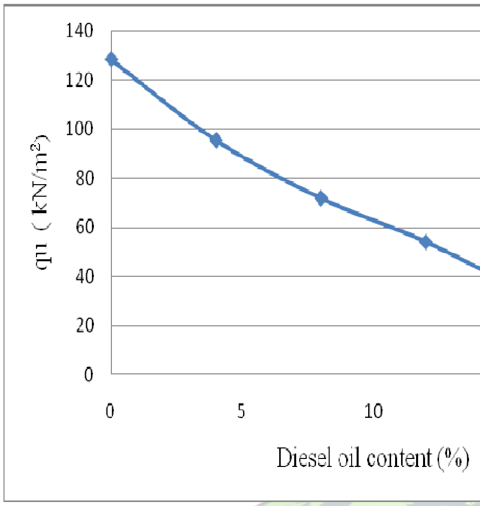

Figure 7: Variation of Unconfined compressive strength of soil with oil content

Settlement characteristics of diesel oil contaminated soil

Figure 8 Shows the settlement characteristics of diesel oil contaminated soil. Settlement of footing increases with the increase in diesel oil contamination in the soil. The diesel oil content leads to decrease in the soil density and looses the soil particles, so it leads to the weakness of soil and decreases the strength

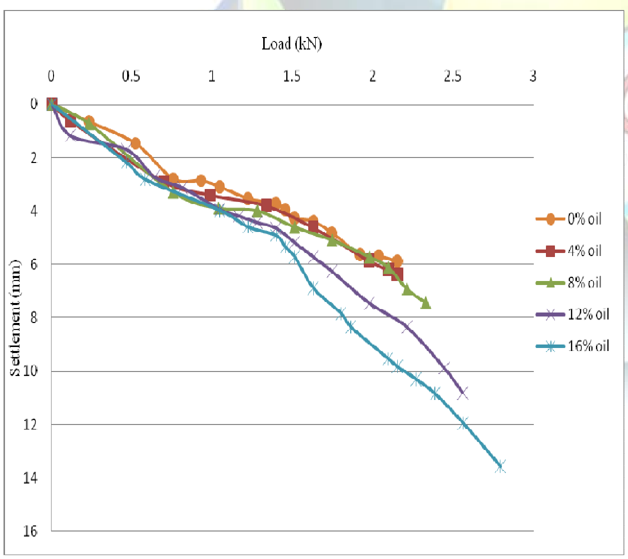

Figure 8 settlement characteristics of diesel oil contaminated soil

Figure 9 shows the variation settlement of soil with oil content. Settlement increases 130% with the increase in diesel oil contamination .16% of oil gives worst strength and max settlement so stabilized the oil contaminated soil at 16% with varying percentage of phosphogypsum

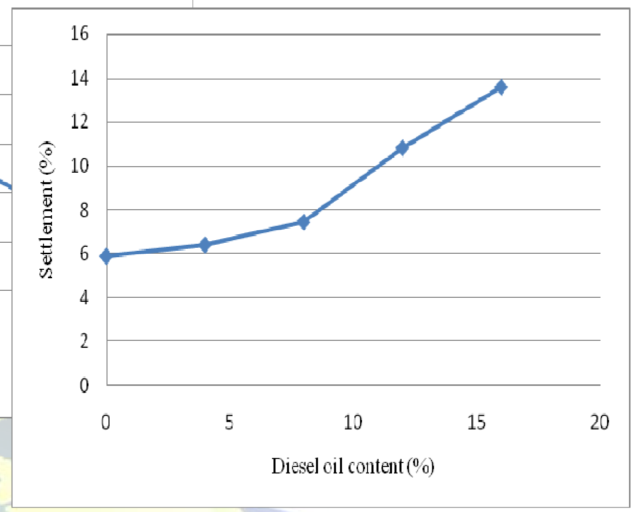

Figure 9 settlement variation of soil with oil content

Compaction characteristics of diesel oil contaminated soil with phosphogypsum

The results of compaction test are shown in figure 10. The optimum moisture content and maximum dry unit weight of soil increases with increasing phosphogypsum upto 9%. The diesel oil in the clay is absorbed by phosphogypsum so it decreases coating of diesel in clay particles so it leads clay particles attracts together and also it absorbs more water to reach maximum dry density.

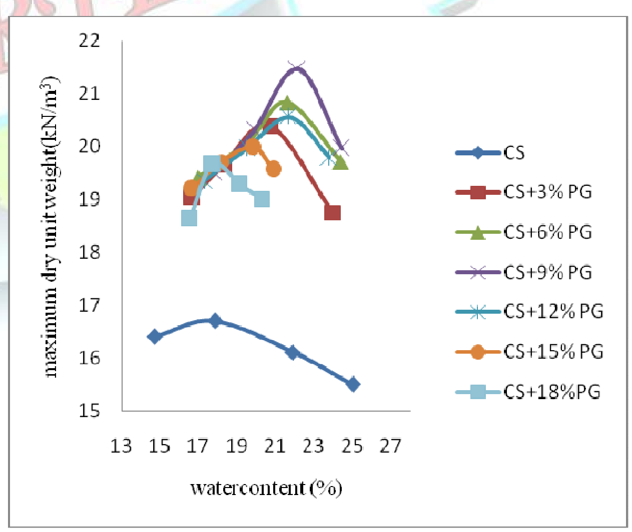

Figure 10 Compaction curves of contaminated soil with phosphogypsum

Figure 11 shows the variation of maximum dry unit weight and OMC contaminated soil with phosphogypsum. Both

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OMC and maximum dry unit weight increases 25%and 30% respectively with increasing % of PG up to 9%

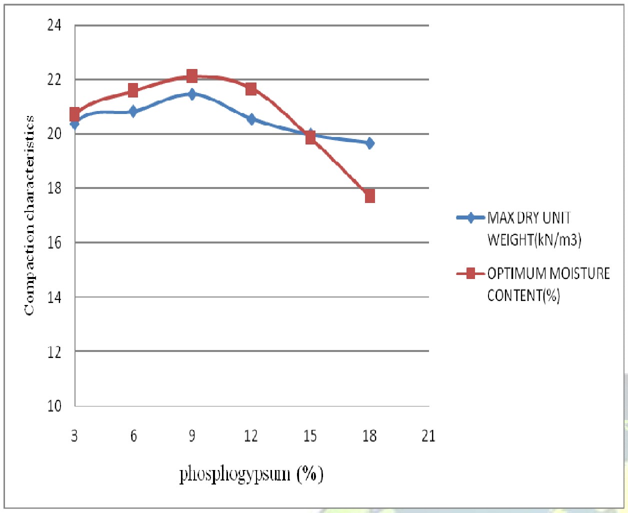

Figure 11 variation of maximum dry unit weight and OMC of oilcontaminated soil with phosphogypsum

Unconfined compressive strength characteristics of diesel oil contaminated soil with phosphogypsum

The Figure 12 Shows the axial stress-strain curve for oil contaminated soil with varying % of phosphogypsum. Unconfined compressive strength (UCS) increases with the increase in phosphogypsum content in contaminated soil up to 9%. Phosphogypsum increases the MDD of soil and also makes the soil particles tightly packed. Predominant content in phosphogypsum is calcium it imparts more strength to the contaminated soil it leads in increases in UCS value

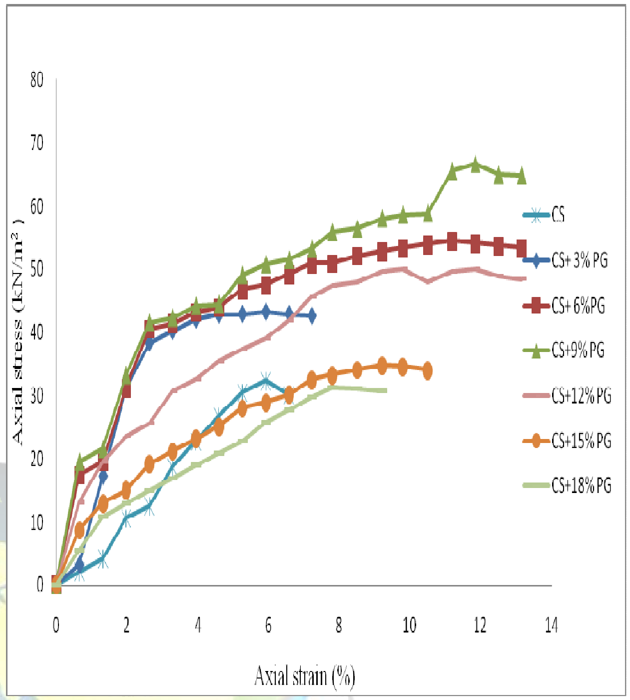

Figure 12 axial stress-strain curve for oil contaminated soil with varying % of phosphogypsum.

Figure 13 shows the variation of UCS of contaminated soil with PG. UCS increases 95% with the increase in phosphogypsum content.

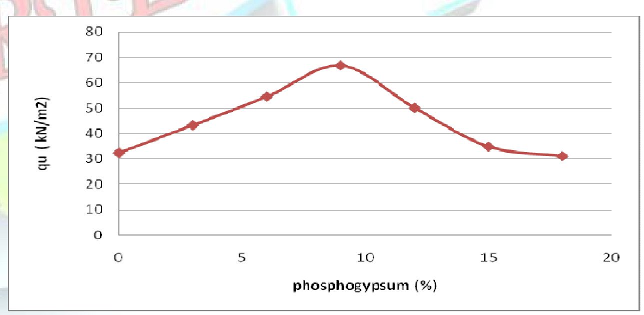

Figure 13 variation of UCS of contaminated soil with PG.

Settlement characteristics of diesel oil contaminated soil with optimum % of phosphogypsum

The Figure 14 Shows the settlement characteristics of diesel oil contaminated soil with optimum % of phosphogypsum. From the above compactions and UCS tests of oil contaminated soil with phosphogypsum it is obtained that 9% is the optimum % of phosphogypsum which imparts maximum strength to contaminated soil. Results from load test shows that settlement of strip footing resting on oil contaminated soil decreases 98% with optimum phosphogypsum content.

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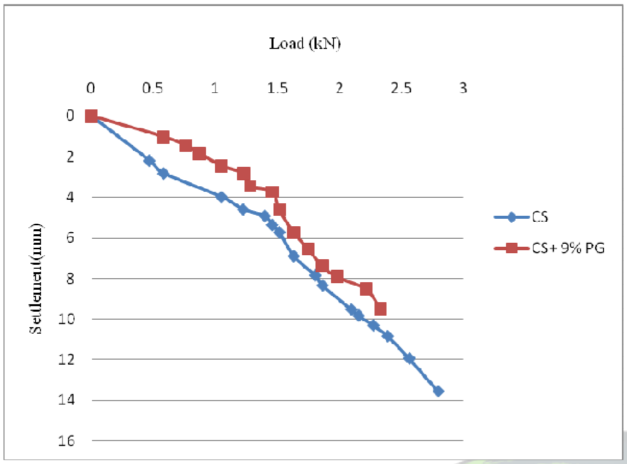

Figure14 settlement characteristics of diesel oil contaminated soil with optimum % of phosphogypsum

CONCLUSIONS

The optimum moisture content, maximum dry unit weight and UCS decreased as the diesel oil content in the soil increased. Addition of diesel oil to the soil resulted in an increase in settlement of the soil. From the all above test results gives 16% of oil contamination gives the worst strength. Stabilizing oil contaminated soil with 9% of phosphogypsum by unit weight of soil gives optimum results. Addition of PG to the oil contaminated soil increases OMC, MDD and UCS values of soil and also it decreases the settlement of footing in oil contaminated zone. From this study it is understood that Phosphogypsum is a good additive for improving the property of diesel oil contaminated soil.

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