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California Bearing Ratio of Some Iraqi Dune Soils

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Abstract

This paper contains the results of CBR tests that performed on compacted samples of real dune sand (cohesionless sand grains) and pseudo dune sand which is a mixture of sand sized aggregate of clay and silt. The effect of compaction and soaking on the bearing values are included in this research.

The results indicated that the compacted real dune sands have high strength and low sensitivity to soaking. The 5 mm penetration of CBR of this soil is higher than that of 2.5 mm. On the other hand, the loss of strength due to soaking can be quite considerable in compacted pseudo dune sands. The CBR values obtained at 2.5 mm and 5 mm penetration are approximately equal in pseudo dune sands.

Keywords: Dune Sand, CBR, California Bearing Ratio, Iraqi Soil

الخلاصة

يتضمن هذا البحث عرضا لنتائج فحوص نسبة التحمل الكاليفورنيي (CBR) التي أجريت على نماذج مرصوصة من تربة الكثبان الرملية الحقيقية (خليط من ذرات الرمل الناعم) وتربة الكثبان الرملية الكاذبة التي هي خليط من دقائق الطين والغرين المتجمعة بشكل ركام بحجم ذرات الرمل الناعم. تضمن البحث ايضا دراسة تاثير جهد الرص والغمر على قيم التحمل.

لقد بينت النتائج إن الرمال الحقيقية المرصوصة تمتلك قوة تحمل عالية وقابلية تأثر بالغمر قليلة. كما إن قيم (CBR) المحسوبة عند اختراق ٥ ملم كانت دائماً أعلى من تلك المحسوبة عند اختراق ٢.٥ ملم . من ناحية أخرى فان النقصان في قابلية التحمل بفعل الغمر كانت واضحة في الرمال الكاذبة المرصوصة ، كما إن قيم CBR المحسوبة عند اختراق٢.٥ و ٥ ملم كانت تقريبا متساوية في هذه التربة.

Introduction

Arid and semi-arid areas occupy about quarter of the total land area of the world (Khan 1982). In Iraq, desert represents more than 50% of the land. The top surface of this desert is covered with about two million hectares of sand dunes. These dunes are distributed in areas like Baiji, Central parts of Iraq, and the west desert (Buringh 1960, Khadair 1997).

Since Iraq is a fast growing country, many parts of the country may be bustled with many construction projects. As a result, the consequent movements of men and materials require a rapid expansion of transportation systems. This may be necessitating construction of new roads and highways on dune sands connecting different new oilfeilds, military, and civil installations. Such cases, however, required large volumes of aggregates of good quality for use in base course, sub base, and the construction of abutment. Therefore, all attempts should be made to utilize the locally abundantly available free of cost dune sands as much as possible. These situations therefore necessitate an investigation of bearing characteristics of these deposits.

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Types of Dune Sands in Iraq

Generally there are two types of dune soil in Iraq. The first type is called real dune sands which consists of more than 90% of poorly graded silica sand. This soil is found in Baiji, Al-Dour, and dune belt extending from the south of Samawa to Kuwait border. The second type is pseudo sand in the middle part of Iraq. This soil vary widely in texture at which the average percentages of clay, silt and sand are 22.1, 18.4 and 59.5 respectively (Al-Taie,1984, Monika Draga 1986).

Experimental Work

The purpose of this work is to investigate bearing values of real dune sand obtained from Baiji (S1), and pseudo sand (S2) taken from dune area north of section R6/B of Iraqi expressway number one near Samawa City.

To achieve the aim of the present work, the physical properties are firstly determined, after that the compaction parameters (maximum dry density and optimum moisture content) are determined. A series of California Bearing Ratio tests (CBR) are conducted. The effect of compaction and soaking on bearing values are also included in this research.

Physical and Chemical Tests

Grain size distribution, specific gravity, Atterberg limits, and chemical tests are conducted on samples selected from both sites (S1 and S2) according to ASTM D422-79, ASTM D854-58, BS1377-1975**.** Table 1 shows these test results.

Compaction Tests

Maximum densities and corresponding optimum moisture content of the soils are obtained by means of standard and modified compaction test in accordance with ASTM D618-70 and D1557-70 standards respectively.

CBR Tests

In order to investigate bearing characteristics of the dune soils, their California Bearing Ratio values are determined. The tests are performed on samples prepared at optimum moisture content and compacted to various densities. A second series of tests are performed on specimens soaked in water for four days to give an indication on strength reduction and swelling due to saturation.

Two series of tests are conducted on each dune soil. For the first series, the preparation of the specimens and testing procedure are generally performed in accordance with AASHTO T143-81. Three specimens are prepared at optimum moisture content of the standard compaction test, and compacted in three layers using standard compaction hammer. Ten, thirty, and sixty five blows per layer are used in the compaction of the three specimens.

Identical specimens are prepared and tested after soaking in water for four days to simulate the effect of saturation on bearing characteristics.

In the second series, the whole program is repeated on specimens prepared at optimum moisture content of the modified compaction and compacted in five layers using modified compaction hammer.

In all these tests, surcharge weights of 4.5 kg in form of annular steel rings, are placed on the top surface of the prepared specimens before testing. The surcharge simulates the effect of the thickness of road construction overlying the layer being tested.

Results and Discussion

Compaction Tests Result

The results of standard and modified compaction test are shown in Fig. 1 and

Table 2. Irregular curves with more than one peak are seen from the compaction curves of S1soil. An initial reduction in density is obtained at low moisture content followed by a gradual increase to the peak value. A sharp fall in density generally occurs on the wet side of the optimum. Lambe and Whiteman 1969, mentioned that the low density that is obtained when cohesionless soils compacted at low moisture contents is due to capillary forces resisting rearrangements of the sand grains. Also, Murthy 1989, indicated that small films of water around the grains can keep the particles apart and can decrease the density up to a particular moisture content. On the other hand, the shape of compaction curves for S2, where the sand is pseudo, is very close to that of normal clays. It is evident that as the molding moisture content is increased the dry density increases to a peak and then decreases.

CBR Test Results

The values of unit loads are plotted against depth of penetration in Figs. 2 and 3. Examination of Fig. 2 reveals that stress and penetration curves for S1 soil consists of an approximate straight portion for about 3 mm penetration then tend to level out with further penetration. Memon (1977) studied the CBR of compacted granular soils in Saudi Arabia. The author stated that the stress and penetration curves of granular soil are more or less directly proportional. They consist an approximate elastic portion for about 5 mm penetration. The stress penetration relationship for clayey soil (S2), (as shown in Fig. 3), exhibits an elastic behavior for penetration less than 3 mm. The same is found by Memon (1977) for clayey soil in Saudi Arabia.

Fig. 4 shows the percent decrease in CBR values due to soaking at different number of blows. This figure reveals that S1 samples undergo a reduction in strength due to saturation varying from 0 to 40 %, whereas the loss of strength due to saturation can be quite considerable in S2 samples (up to 90%). On the other hand, the decrease in CBR values for S1 samples compacted with standard hammer is greater than that of samples compacted with modified hammer. Conversely, the decrease in CBR values of S2 soil is greater when modified hammer is used. This behavior is due to the nature of each soil and the difference in structure that occurred due to compaction. Monika Draga (1986), and Al-Soud,. (2000), mentioned that pseudo dune sands are unusual deposits, predominantly silt and clay, while real dune sands are fine, poorly graded silica sand with nearly no fines. Actually the presence of water greatly affects the engineering response of the fine grained soils much more than coarse grained soils. For fine grained soils, water affect the interaction between the mineral grains, and this may affect their plasticity and their cohesiveness, Holtz and Kovacs, (1981).

A summary of all CBR soaking test results for both soils at 2.5 and 5 mm penetration are presented in Fig. 5. It is noticed that for (S1) samples the CBR at 5 mm penetration is consistently higher than the values corresponding to 2.5 mm penetration, while the CBR values obtained at 2.5 and 5 mm penetration are approximately equal in S2 samples. The higher CBR values are obtained at 5 mm penetration for S1 soil, where the soil is real sand and containing lower percentage of material passing sieve of 200 mesh. This is an indication of easier pore water pressure dissipation under the CBR plunger. Memon (1977) stated that the 5mm penetration CBR of the granular soils as determined in the laboratory is higher than that of 2.5 mm penetration CBR. He concluded that the

CBR plunger acting like a footing is supported on the soil which behaves similarly to an elastic medium and does not reach the plastic stage up to about 5 mm penetration.

Figs. 6 shows the correlation of the soaked CBR values with number of blows for both soils. It can be noticed that CBR values increased with the increase of number of blows and weight of hammer used. Fifty six blows per layer are generally required to mold CBR specimen to hundred percent of the maximum dry density determined by ASTM D678-70 and D 1557-70. At this number of blows, a soaked CBR values of 6.4 and 11.6 are obtained for S2 soil whereas for S1 soil, soaked CBR gives consistently high values in the range of 20-40%. On the basis of these results and to rate the performance of these deposits primarily for use as bases and subgrades beneath pavements of roads, S2 and S1 dune soils can be rated as “Poor to fair” and “Good” respectively, Bowles(1981).

The swelling characteristics of the dune soils are also investigated. Specimens are soaked in water for a period of four days and swell reading are taken during this period at arbitrary selected times. It is found that S1 soil do not have any swelling potential, while S2 samples undergo considerable swell (more than 4 %) as shown in Fig. 7. This result is expected, because of the real mineralogical composition of S2 soil that consists of high percentage of clay minerals, while S1 soil consists of quartz, which does not have any swelling potential. Fig. 7 also indicated that the initial swelling of S2 soil compacted with standard hammer is greater than that obtained when modified hammer is used. Conversely, the final swelling of S2 soil compacted with standard hammer is less than that compacted with modified hammer. This behavior may be attributed to the initial water content and initial void ratio which is less in samples compacted with modified hammer.

Conclusions

1. When compacted, real dune sands undergo small reduction in strength due to soaking , whereas, the loss of strength due to soaking can be quite considerable in compacted pseudo dune sands.
2. Compacted real dune soil exhibit higher CBR values than compacted pseudo dune soil. Moreover, the 5 mm penetration CBR of the real dune sands is higher than the 2.5 mm penetration CBR, while the CBR values obtained at 2.5 mm and 5 mm penetration are approximately equal in pseudo sand.
3. Unlike pseudo sands, real dune sands can be used as a good materials in bases and subgrades beneth pavements of roads.
4. Compacted pseudo dune sands wetted under the surcharge weight undergo a considerable swell, while compacted real dune sands do not have any swell potential.

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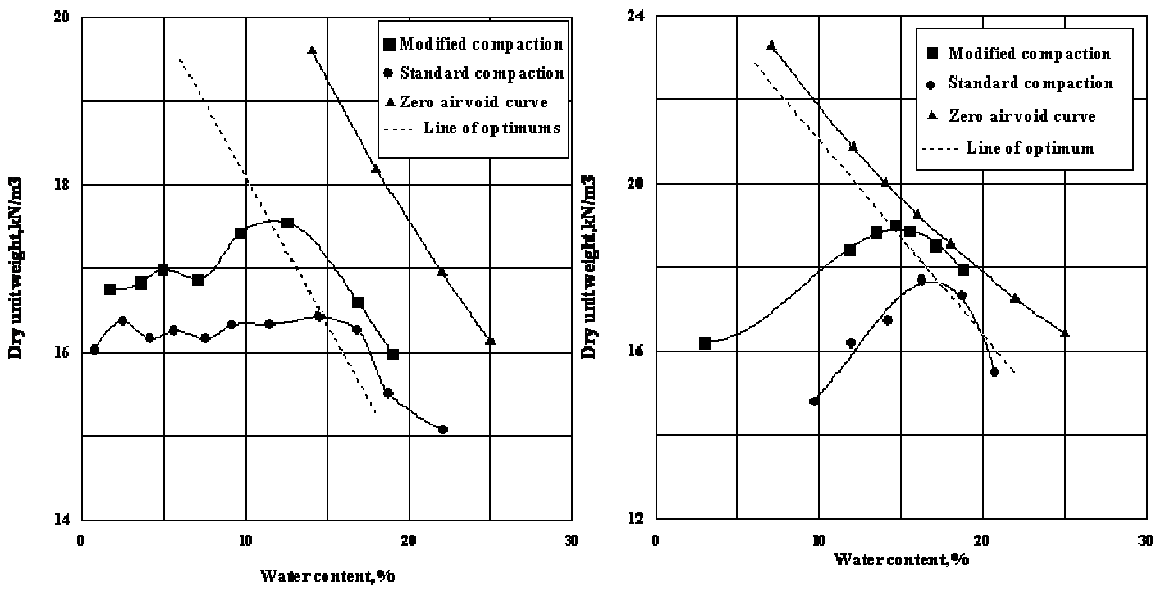
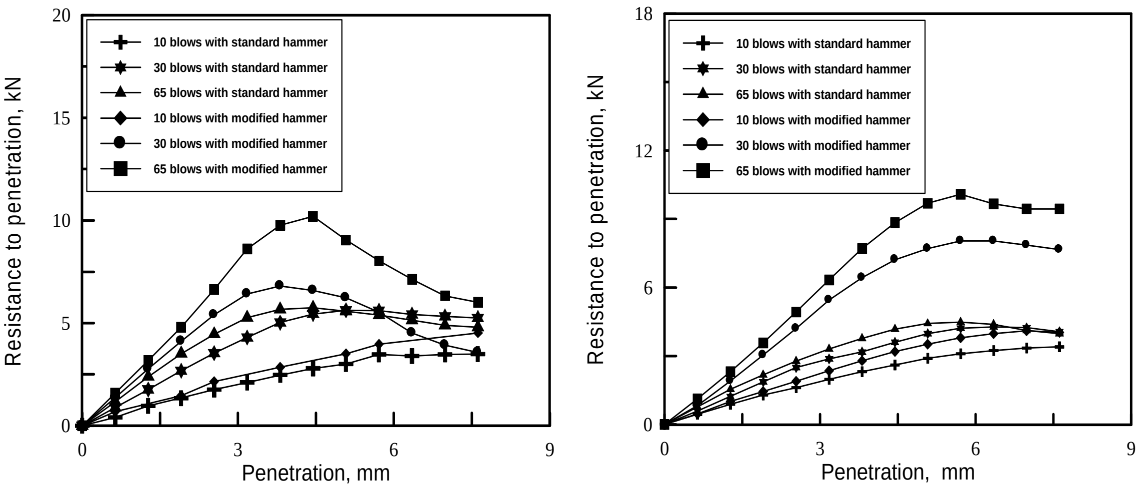


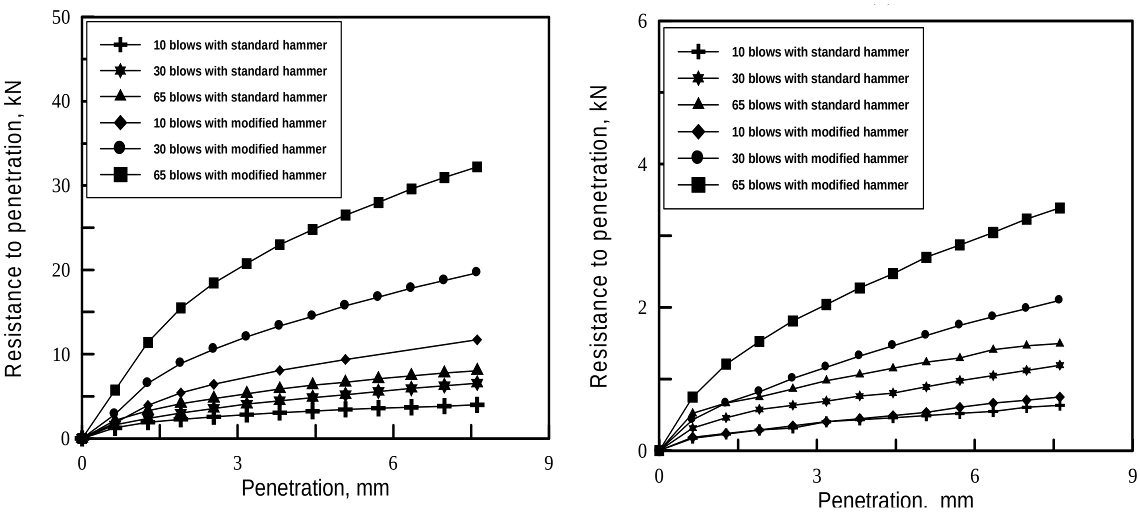
(a) S1 (b) S2

Fig. 1: Compaction Curves



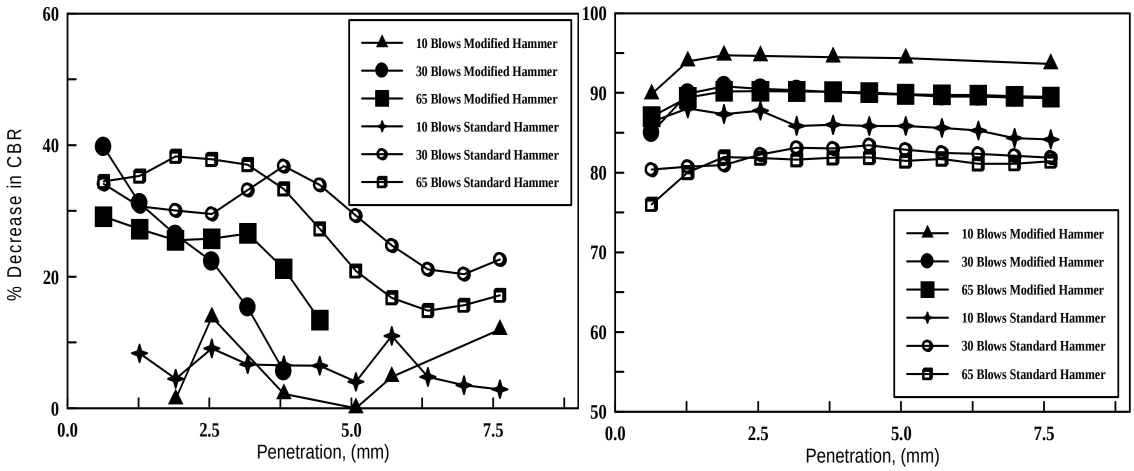
(a) Unsoaked Samples (b) Soaked Samples

Fig. 2: Load- Penetration Curves from CBR Test for (S1) Soil.



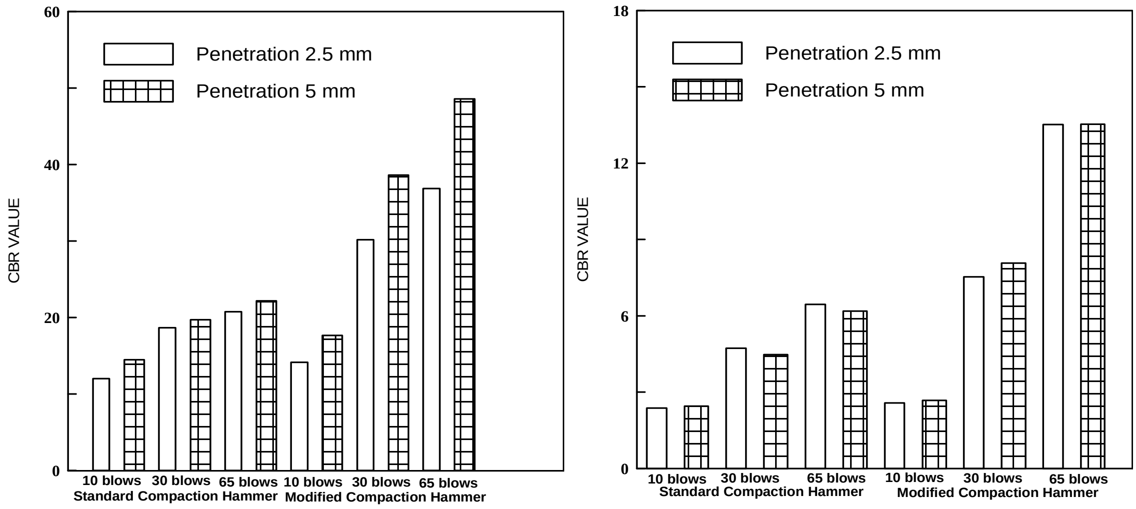
(a) Unsoaked Sample (b) Soaked Samples

Fig. 3: Load- Penetration Curves from CBR Test for (S2) Soil.



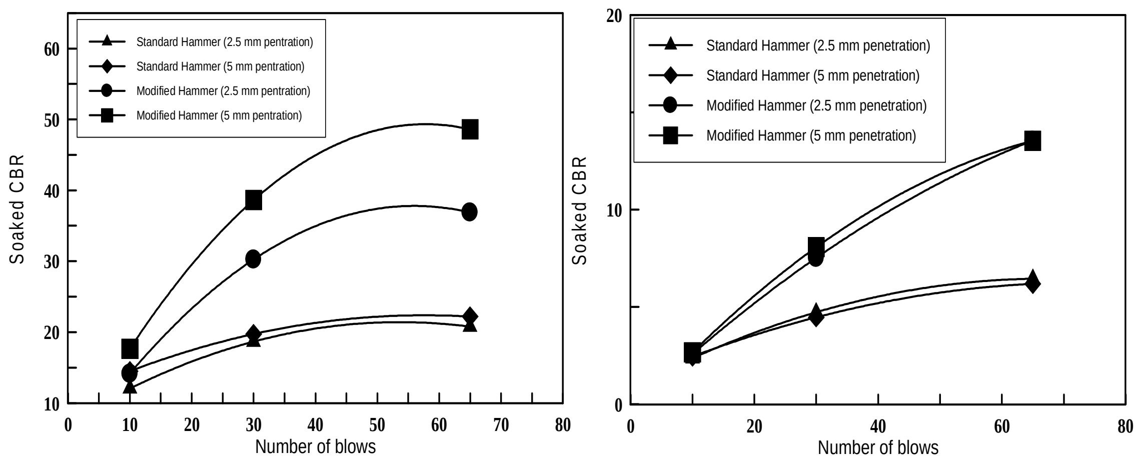
(a) S1` (b) S2

Fig. 4: Percent Decrease in CBR Values Due to Soaking.



(a) (S1) Soil (b) (S2) Soil

Fig. 5: CBR Values at 2.8 and 5 mm Penetration



(a) (S1) Soil (b) (S2) Soil

Fig. 6: Number of Blows per Layer versus CBR

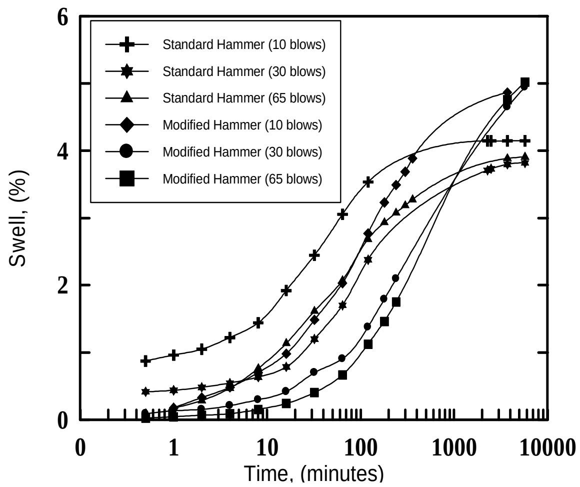


Fig. 7: Swelling Tests For (S2) samples

Table 1: Summary of Classification and Chemical Tests

Soil Property		Soil Type (S1)	Soil Type (S2)
Wet Sieving Analysis	% Sand	98	38
	% Fines(Silt/Clay)	2	(35/27)
Coefficient of Uniformity		1.95	114.60
Coefficient of Curvature		1.49	0.26
Specific Gravity,G_s		2.70	2.78
Atterberg Limits	L.L.	-	38
	P.L.	-	20
	P.I.	NP	18
Unified Soil Classification System		SP	CL
AASHTO classification system		A3	A6
Chemical Tests	SO_3 (%)	0.07	2.60
	Cl (%)	0.026	0.42
	Gypsum content (%)	0.27	5.80
	pH	8.10	8.80

Table 2: Summary of Compaction Tests

Soil Type	Soil Property	Standard Compaction	Modified Compaction
S1	Maximum dry density (kN/m^3)	16.42	17.55
	Optimum water content (%)	15.00	11.50
S2	Maximum dry density (kN/m^3)	17.50	18.93
	Optimum water content (%)	17.60	14.50