AN APPROACH IN IMPROVING THE PROPERTIES OF SAND DUNES

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ABSTRACT

An experimental study to improve sand dunes to gain economic construction of highway using these locally available materials. The study was divided into two approaches; the first was by using different bituminous binder proportions from (2) to (10) percent, while the second was to use fine metals as reinforcement. The results show an increase in the degree of improvement as reinforcement layers and silt contents were increased. Also it was found that 8% 0f asphalt cement increase the stabilization of sand dunes.

الخلاصة

أجريت دراســات مختبرية لتحسين الكثبان الرملية للحصول على مادة إنشائية اقتصاديةلاستعماها كمادة انشلئية محلية في أعمـــال الطرق .قسمت الدراسة إلى اتجاهين الأول باستعمال المحتوى الإسفلتي بنسب من (2)% إلى(10)%بينما الاتجاه الثاني باستعمال شبكات التسليح

تبين من النتائج إن هناك زيادة في درجة التحسين كلما زادت طبقات التسليح مع زيادة نسب الغرين.كذلك وجد أن النسبة 8%من الإسفلت الأسمنتي قد سببت زيادة في تثبيت الكثبان الرملية.

KEYWORDS

Sand Dunes, Local, Reinforcement, Asphalt, Triaxial

INTRODUCTION

In south of Iraq, especially between Nasria and Basrah, sand dunes of uniform size are available in abundance and can be used for low- cost stabilizer constructions. Obviously these soils may be improved its properties and behavior in order to use it in project for strategic use as bridges, road, and building. Obviously, these roads should be constructed at much cheaper cost, using the locally available sand which are stabilized with bitumen and could be improved also by reinforced such types of soils which is one of considered methods in improvement for these in this study.

Reinforced Earth is a composite of material formed by the association of granular fill and tensile resisting elements (strips, grids or sheets) as reinforcement. This concept is totally based on the friction mobilized between the reinforcement and the soil grains surrounding it. Due to this interaction to a tensile normal load on the reinforcement mass will be transferred to a tensile force along the reinforcement. Consequently the reinforcing element will act as a tie between the particles of the fill material.

The modern technique was introduced by Vidal and earliest studied were dealt with retaining walls such as the work of Lee et al, AL-Hussainy and Perry and others. Then the advantage of reinforced earth as foundation material attracted many investigators who studied the bearing capacity of reinforced earth slabs or subgrades, Binquet and Lee, Akinmusurg and Akinbolade.

Almost all types of sand and sandy soils have been successfully stabilized by the addition of bituminous materials like cutback emulsions or low viscosity straight run asphalt. Bituminous binders, when used as additive to non- plastic sand proved sufficient cohesion to develop resistance to displacements under wheel loads. The cementing process of sand – bitumen mixes is more effective when these are highly compacted at ambient temperature such stabilized and bitumen materials be used as sub-base or base courses for flexible pavements as studied by Singh et al (1979).

- DUNE SAND:

The sand dunes were obtained from the dunes area south of Iraq, between Nasria and Basrah with specific gravity of (2.69) and gray in color.

-GRAIN SIZE DISTURBUTION:

Fig. (1) gives the grain size distribution; it is mainly fine sand and has a sigmoid shape with a very well sorting.

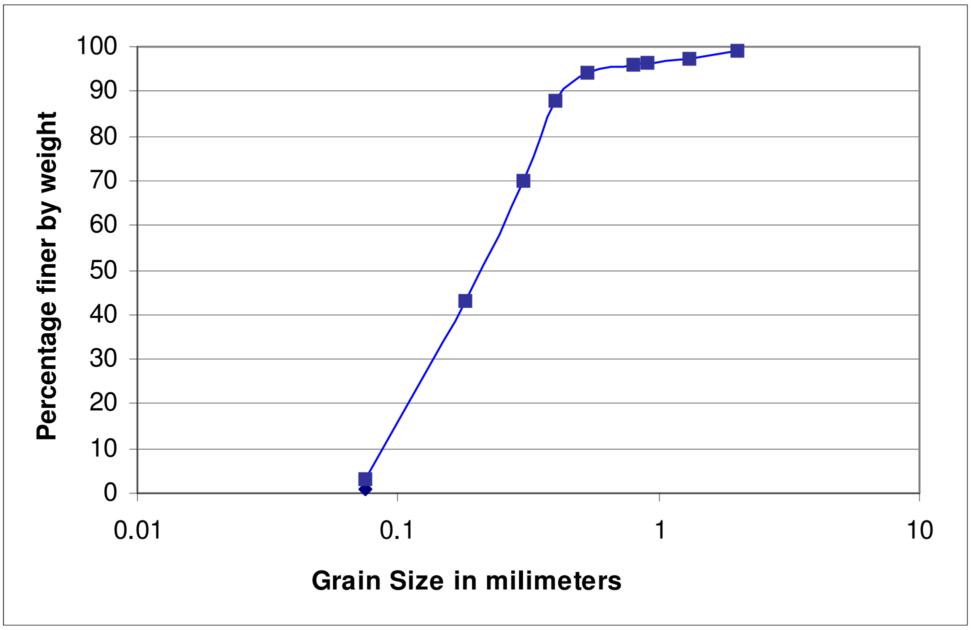

Fig (1). Grain size distribution of dune sand

-ATTERBERG LIMITS

Laboratory tests for liquid limit and plastic index determinations were conducted. The soil was found to be completely non- plastic in character.

-DRY DENSITY

The maximum dry density of the dune sand as determined is (1.7) gm/cm^3, while the minimum dry density was found to be (1.25) gm/cm$^{3.}$ The filling density used throughout the tests was (1.45) gm/cm$^{3\ which}$ gives a relative density of (51.9)%. The angle of internal friction of dune sand at this density is (29)$^\circ$ as determined from direct shear test.

-BITUMINOUS MATERIALS

The road paving bituminous materials, as asphalt cement (85/100), RC selected for stabilization, for various reasons including their commercial and availability in large quantity and the ease of mixing with sand. These binders were tested according Iraqi standard specification.

REINFORCED TYPE:

The suggested type of reinforced used are fine metal wire mesh. The properties of this material are shown in table (1).

Table (1) properties of reinforcement used in the test

Type of reinforcement	Aperture size (mm)	Thickness (mm)	Tensile strength (kPa)
Fine wiremesh	1.7 x1.7	0.7	27.3

TEST PROCEDURE

STABILIZATION BY BITUMINOUS MATERIALS:

TEST PROCEDURE:

Marshall Stability or Hveen stabilometer tests are commonly used to determine stability of sands for sand bitumen mixes as mentioned by Klarkson (1965).

Sand dunes and the selected grade of bituminous materials were heated separately to (160 C°) and then mixed together in required proportion till a uniform color was obtained. Moulds of (4) cm in diameter (2.5) cm in height of Marshall stability apparatus were then prepared and tested at (60 C°). Different bituminous binders in percent age varying from (2) to (10) percent by weight of sand dunes were used.

. AGING AND CURING:

The half of specimens from each trial was subjected to aging in air at room temperature for (1), (7), and (15) days. The other half of sand – bitumen mix was subjected to curing in water for (1), (7), and (15) days. In both samples, A/C (85/100) and RC as a binder were used.

. IMPROVING BY REINFORCED TYPES:

The samples used in the triaxial tests were (38) mm in diameter and (76) mm in length. All the samples were prepared by pouring the sand inside the triaxial mold in three layers. Each layer was compacted (using wooden tamping rod) to the required density. The reinforcing layers placed at the specified spacing provided that the uppermost and lowermost of reinforcing layers are located at half of the spacing from the top and bottom of the sample.

The conventional triaxial testing techniques as suggested by Bishop and Henkle were used in the investigation. Also to study the improvement which could be obtained in adding fine soil passing #200? In the preparation of unreinforced and reinforced sand dune, different percentages of silt were added to the sand dune in order to investigate their effect on the strength of the reinforced soil. Table (2) is representing the main test program.

Table (2) Main test program

Series of tests	Type of reinforcement	No. of reinforcing layers (N)	Silt content %
1ST	Fine metal wiremesh	0,1,2,3	0
2nd	Fine metal wiremesh	0,2	10,25,50,60

The all round pressure (σ_3) was selected to be (100) kN/m^2 throughout the tests. A consolidated – Undrained Triaxial test were conducted. The rate of deformation was (0.6) mm/ min (chosen according to operation manual of W.Ferrance Company of Triaxial Test).

TEST RESULTS AND DISCUSSIONS:

Stabilization by bitumen:

The test results for marshal stability values for various sand- bitumen mixes tested reported in table (3) and represented graphically in figure (2), (3), (4), and (5).

A steady rise in the stability value is initially observed with increasing binder content up to an optimum binder content, beyond which it decrease. The fall in stability value is very sharp in the case of cutback (Rc). The maximum stability value is obtained at (8) percent for (A/C) (85/100) and (Rc), for one day aging (10.70 and 5.74 kN).

From the results it is also observed that (A/C 85/100) prove to be the best binder for (8) percent of sand- bitumen mixes.

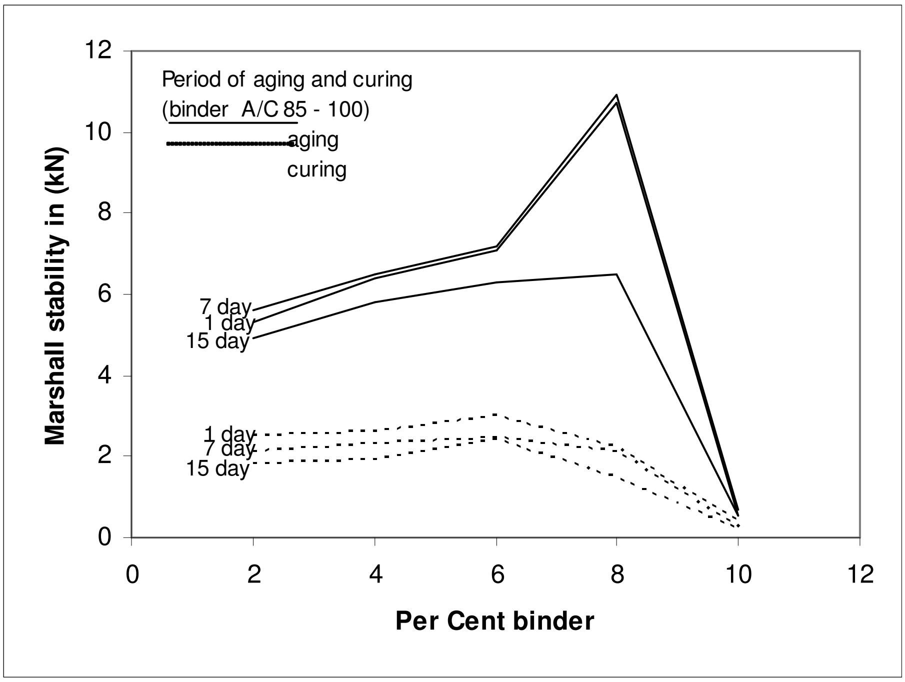

Fig (2). Marshall Stability vs. percent binder

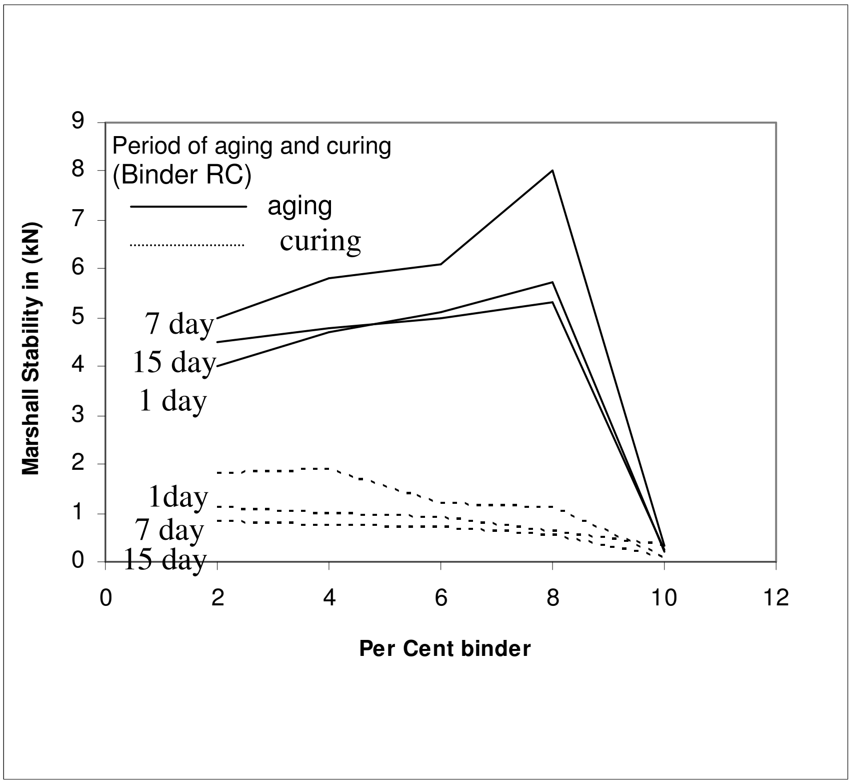

Fig (3). Marshall Stability vs. percent binder

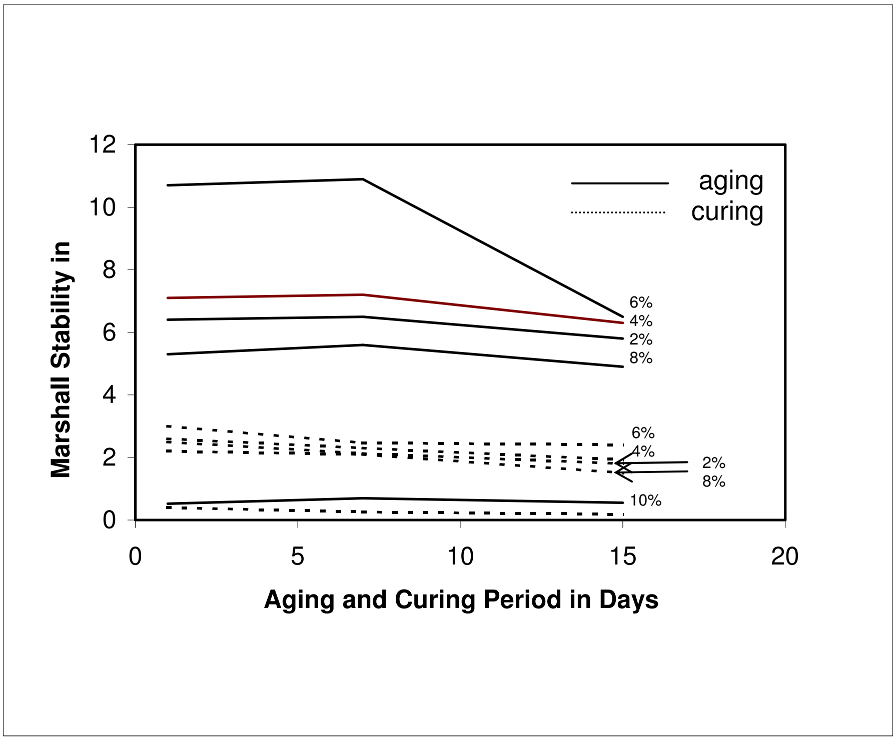

Fig (4). Marshall Stability vs. aging and curing of specimens (Binder A/C 85 – 100)

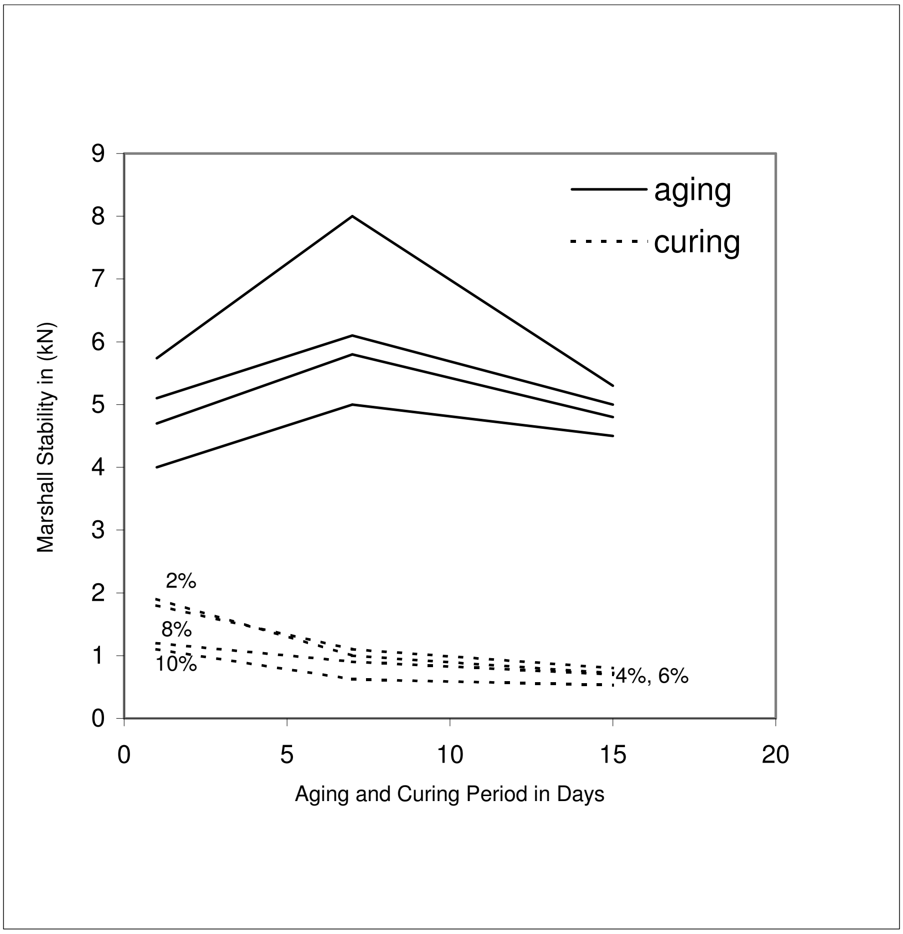

Fig (5). Marshall Stability vs. aging and curing of specimens (Binder R.C.)

Table (3) Effect of aging and curing Marshall stability (kN) 0f Sand-Bitumen at 60^0

Stabilize No.	Binder	% Binder	1Day aging and curing		7Day aging and curing		15Day aging and curing	
			aging	curing	aging	curing	aging	curing
1	A/C 85 - 100	Sand +2%Binder	5.30	2.50	5.60	2.13	4.90	1.80
2	A/C 85 - 100	Sand +4%Binder	6.40	2.60	6.50	2.30	5.80	1.92
3	A/C 85 - 100	Sand +6%Binder	7.10	3.00	7.20	2.47	6.30	2.40
4	A/C 85 - 100	Sand +8%Binder	10.7	2.20	10.9	2.10	6.50	1.50
5	A/C 85 - 100	Sand +10%Binder	0.52	0.40	0.70	0.26	0.55	0.18
6	RC	Sand +2%Binder	4.00	1.80	5.00	1.10	4.50	0.80
7	RC	Sand +4%Binder	4.70	1.90	5.80	1.00	4.80	0.72
8	RC	Sand +6%Binder	5.10	1.20	6.10	0.90	5.00	0.70
9	RC	Sand +8%Binder	5.74	1.10	8.00	0.62	5.30	0.53
10	RC	Sand +10%Binder	0.20	0.10	0.32	0.32	0.24	0.07

EFFECT OF AGING AND CURING ON STRENGTH:

Aging have been increased stability for (7) days for both binder (A/C) and (Rc) [figure (2), (3)], while the curing have been decreased stability for (7) and (15) days [Figure (4), (5)] and the results were tabulated in table (2). It could be noted that for both binder the stability value increases with increasing period of aging to (7) days and stability values begun to decrease after (7) days period. Sand- bitumen mixes having optimum binder contents have shown the least – improvement of strength.

Reinforcement OF Sand Dunes:

The relationships between stress- strain for dune sand and that provided with different layers of wire mesh reinforcement are plotted in fig. (6). It is obvious that the results of reinforced samples showed well-defined peak stress in contrary to the reinforced sand dunes, these results confirmed the results obtained by Al-Abdullah et al (1993), also it could be considered as identical with the failure criterion adopted by Akinmusuru and Akinbolade.

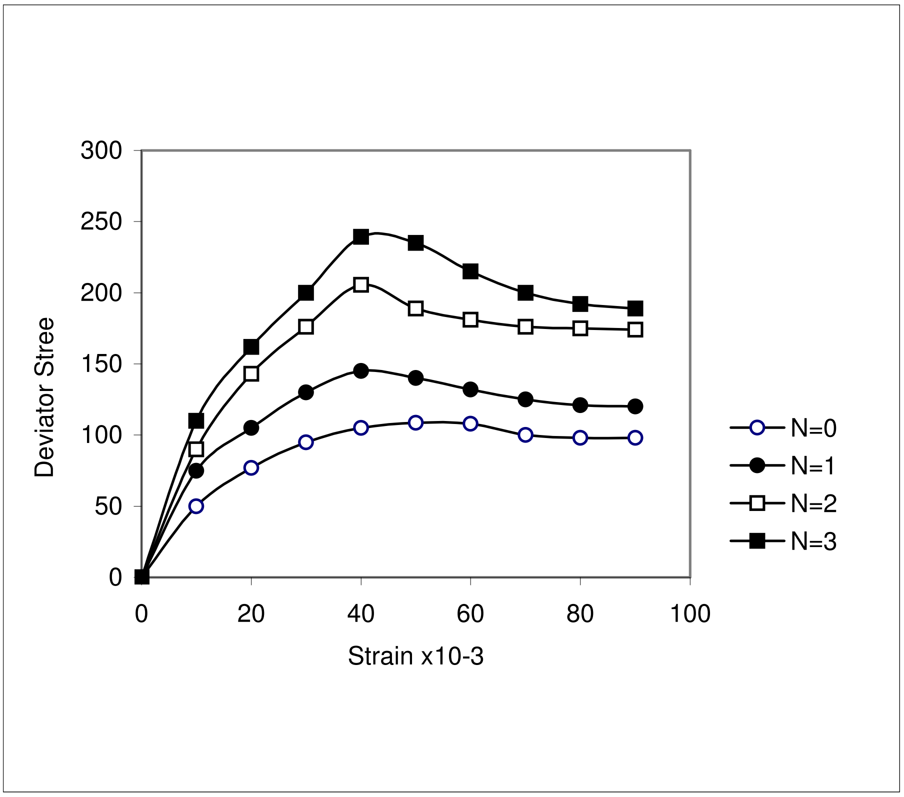

Fig (6). Stress-strain relationship of dune sand with different Layer of wire mesh reinforcement

The benefit of these results could be clearer if the results were expressed in term of Degree of Improvement (D.O.I.) which is the ratio of the peak deviator stress of reinforcement soil to the peak deviator stress of unreinforcement soil. It is clear that the deviator stress at failure increased with the increased of (D.O.I.), this also confirmed by AL-Omari (1989). The results shows that reinforcement of the three reinforcing layers (N=3) gave largest degree of improvement for silt content equal to (0)% as shown in Fig. (7). While the D.O.I. not much more than that for two reinforcing layers, these results could be attributed to the interaction between the soil particles and the wire mesh which helped to transmit the stress on a large area, much more that was from (N=3).

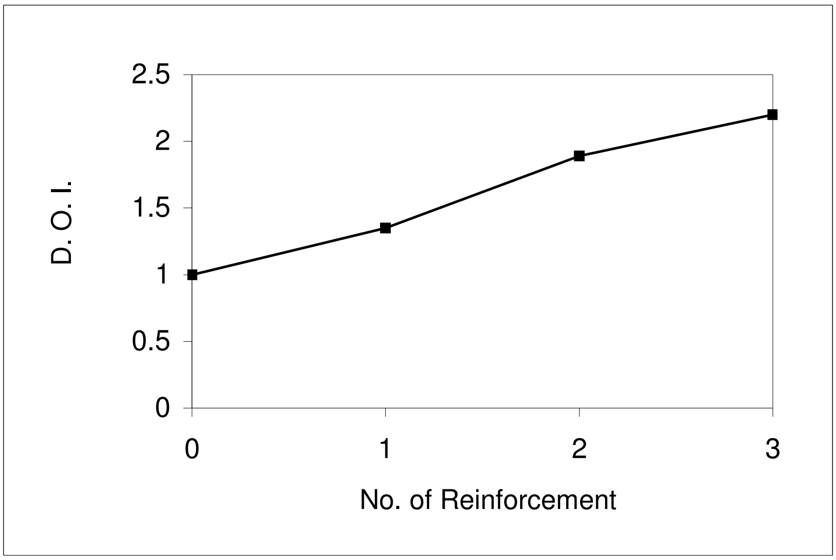

Fig (7). Degree of improvement against number of reinforcing layers (N)

The effect of adding variable percentage of silt (10, 25, 50, and 60)% on stress-strain relationship to the sand dunes could be shown in Fig. (8). Also the variation of peak deviator stress of unreinforced and reinforced for different percent of silt with degree of improvement were shown in table (4). The optimum silt content (that gives maximum deviator stress and degree of improvement) was found to be (25)% for unreinforced sand dunes.

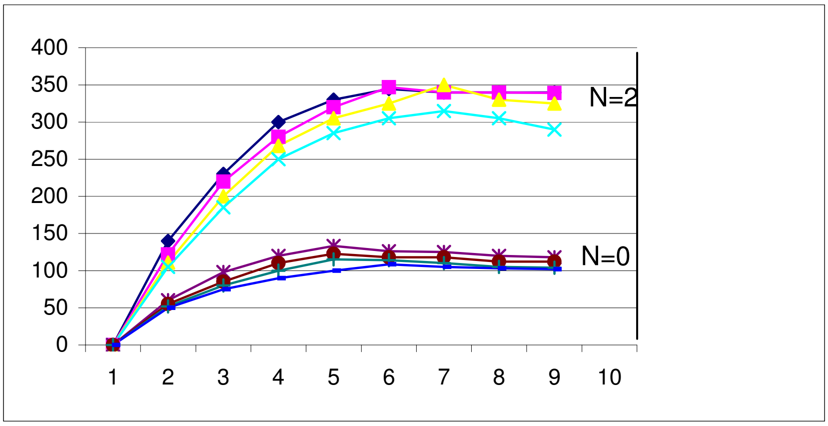

Fig (8). Stress-strain relationship of unreinforced and reinforced Dune sand with different percent of silt

They can be attributed to presence of fine particles surround the reinforcing in addition to the friction mobilized between the reinforcement and surrounding soil.

Table (4) Degree of improvement of dune Sand with different silt contents

Silt content %	Strength of non reinforced dune sand kPa	Strength of reinforced dune sand(N=2) kPa	D.O.I.
0	108.68	205.5	1.89
10	115.39	312.42	2.71
25	122.81	346.68	3.1
50	133.35	344.69	2.58
60	142.41	340.25	2.38

CONCULUSIONS:

From the basis of the last results and their discussions, the following conclusions are derived:

1. Sand dunes have no stability and could be not used for road construction purpose without stabilization and improvement and it could be improved by using fine wire mesh metal reinforcement.
2. Stability of stabilized sand dune increased as high as (10.70) kN when stabilized with bituminous materials.
3. Aging process for specimen increases the stability value over period of (7) days for both binders.
4. The degree of improvement shows an increase in shear strength at silt content of (25)% to the reinforced sand dunes.
5. Sand Dunes could be improved by using fine wire mesh metal reinforcement. The degree of improvement showed an increasing by addition of reinforcement and is proportional with the number of reinforcing lager.

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