SAND DUNES MODIFICATION BY NATURAL ASPHALT WITH CEMENT AND LIME

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Abstract:

This laboratory research program was carried out to investigate the feasible use of locally available material, which is natural asphalt from Heet city, to improve the prevalent sand dunes. The test program was divided into two groups the first one is by adding (5, 7.5 and 10%) natural asphalt, while the second is by adding Portland cement and lime (3 , 6 and 9%) individually to sand-asphalt mixes. Series of laboratory tests are carried out including classification, Marshall stability and unconfined compression Tests

Generally, this study displayed significant improvement in the performance of sand dunes by using natural asphalt, that can be used in stabilization as economic and available material instead of industrial asphalt.

الخلاصة:

تم إجراء هذا البحث المتضمن برنامج فحوصات مختبريه لمعرفة تأثير استخدام مادة متوفرة محليا هي القير الطبيعي من مدينة هيت في تحسين خواص الكثبان الرملية السائبة. تم تقسيم برنامج الفحوصات إلى مجموعتين الأولى بإضافة (٥ ،٧,٥ و ١٠%) القير الطبيعي بينما الثانية بإضافة الاسمنت البورتلاندي و النوره بنسبة (٣ ، ٦ و ٩%) كلا على حده الى خلطات الرمل–القير الطبيعي. تم إجراء سلسلة من الفحوصات المختبرية بضمنها فحوصات التصنيف و ثبوتية مارشال و فحص الانضغاط غير المحصور.

بصورة عامه هذا البحث اظهر تحسن واضح في أداء الكثبان الرملية باستخدام القير الطبيعي، بحيث يمكن استخدامه في تثبيتها بدلا من القير الصناعي.

Introduction:

The interaction between wind and land surface can in most parts of the world results in serious consequences for any type of land occupation. Wherever a granular soil surface is left unprotected it can become victim of wind erosion and dune formation can occur (1).

Sand dune, which is a windblown sand, covers large areas of Iraq. It is characterized as uniform soil with low strength and high permeability. Construction of strategic projects require utilizing this locally available soil in the most effective manner by using stabilization techniques.

The purpose of modifying such soils is to increase shear strength, reduce permeability and volume change potential and render sand vulnerable to losses through wind and water erosion.

There are many well-known methods to improve sand dune that may have potential application in improving the engineering properties of sand dunes including lime, cement, emulsified asphalt, cutback asphalt, cement kalin dust and chemical stabilizers (2,3,4).

Asphalt stabilization has been used as an efficient means to improve the inferior properties of soils having a maximum percentage passing the No.200 sieve of less than 25%, with a plasticity index less than 6%, sand equivalent value of less than 30%, and the product of the plasticity index and the percent passing the No.200 sieve lass than 72 % (5).

Almost sand and sandy soils have been successfully stabilized by addition of bituminous materials like cutback emulsion or low viscosity straight run asphalt. Bituminous binders, when used as additive to non-plastic sand proved sufficient cohesion to developed 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 pavement as studied by Singh et al (6).

Natural asphalt presents in the world within various forms such as natural asphalt lakes on the surface of the earth and in the forms of surface and sub-surface mines and quarries. It is used in pavement of agricultural and service roads and other treatments, and global demand on natural asphalt is expected to increase as a result of high prices of industry asphalt (7).

In Iraq large quantities of natural asphalt deposits are available in Heet city within Al-Anbar Province. Table (1) shows that the properties of natural asphalt have a great simulated with the asphalt samples resulted from refining Iraqi petroleum (8).

Table (1): Comparison between properties of natural asphalt and standard properties of asphalt resulted from refining Iraqi petroleum (8)

Property	Natural Asphalt	Standard Properties (9)
Penetration (25 ^{o}C)	31.16	40-50
Ductility (25 ^{o}C)	75.33	100
Softening Point (^{o}C)	63.5	49-58
Ash content %	2.97	-
flash point (25 ^{o}C)	226	240
Specific Gravity	1.01	1.04
Solubility in CCl4	87.33	99
Loss by Heating	7.5	0.5

Materials and Testing

Materials:

This study conducted using dry samples obtained from the sand dune area in western desert of Iraq, about 70 km west of Al-Ruttba city. Obtained soil was subjected to identification and chemical tests to determine their engineering properties, including sieve analysis, specific gravity and Atterberg limits.

The grain size distribution is shown in Fig. 1. It is observed that sand dune is clean poorly-graded sand (SP) and the specific gravity is 2.67 with no plasticity. Some chemical properties are listed in table (2). Natural asphalt from Heet area selected for stabilization for various reasons including availability in large quantity and poses a health hazard and a potential pollution source. So, Consuming such material in civil engineering works to upgrade marginal materials, would help solve some of these problems. Portland cement (Type I) and Locally produced hydrated lime were also used in small quantities as a combined stabilizer with asphalt sand mixes.

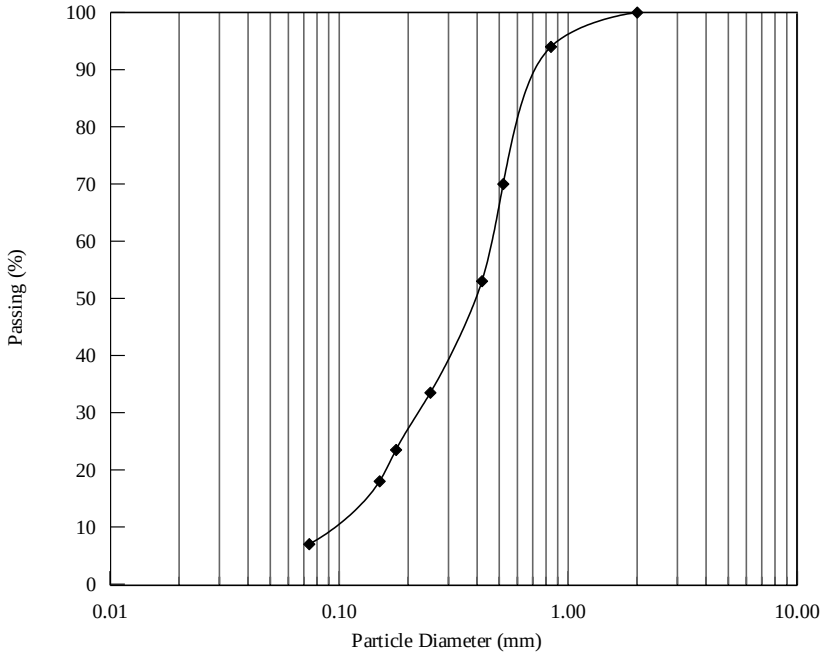

Fig. (1): Grain size distribution of sand dune

Table (2): Chemical Properties of Sand

pH	7.8
SO3 %	0.113
T.S.S %	0.655
Gypsum %	0.243
Cl^{-1} %	0.013

Testing Program

Test procedure:

Flow chart of the testing program is shown in Fig. 2. The work plan consisted of adding different percentages of natural asphalt to dune sand (5, 7.5 , and 10%) by weight of sand. Small percentages of Portland cement and lime were added (3, 6, and 9%) to 7.5% asphalt mixes to accelerate curing and to improve the early age mix properties of asphalt soil mixtures. Similar experimental design was followed by the authors(10 and 11).

Optimal asphalt content was determined by the Marshall mix design method. A Marshall hammer was used to prepare test specimens by applying 75 blows on each side. The prepared specimens, after curing period, were tested using Marshall apparatus according to(ASTM D1559-00) (12) .

Unconfined compression specimens (38 x 76 mm) were compacted to the same density as Marshall specimens by utilizing the rodding compaction procedure that recommended by Head (1982) (13). After curing period, specimens were tested according to the UC-test procedure (According to ASTM D2166-00) (12).

Curing Time:

Half of specimens from each mixture were allowed to aging at laboratory temperature (about 24 C^o) for (7) days for hardening or cementation of the additive-soil mix. Since the probability of exposure to moisture during the stabilized materials performance life in a pavement system is extremely high, the other half of specimens were allowed to cure in water for (7) days to investigate the effect of soaking on additive-soil mix.

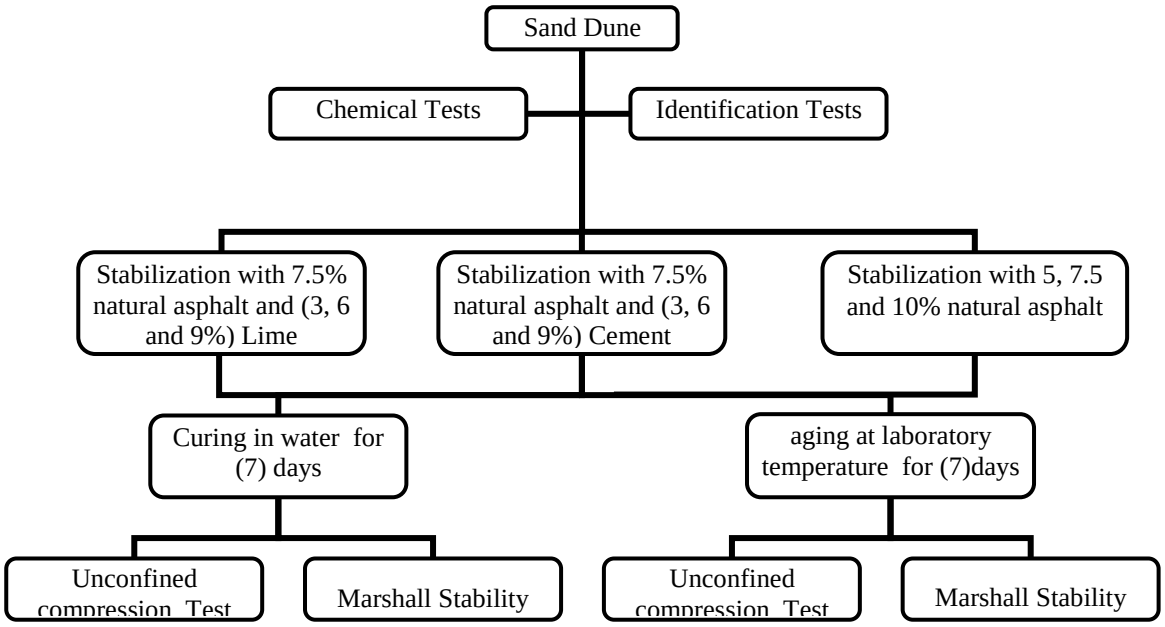

Fig. (2): Flow chart of the testing program

Results and Discussion

Natural Asphalt Stabilization:

The tests results for Marshall stability values for various sand-asphalt mixes are shown in fig.(3). The pattern indicated by the curve on the figure shows an increased stability values with higher asphalt content up to 7.5% then the state is reserved. Fig. (4) shows clearly that increasing the asphalt content resulted in increasing flow of stabilized soil. Fig. (5) shows the results of unconfined compression test. It is clearly noticed that an increase in treatment

material percent leads to increase the unconfined compression strength. This trend can be attributed to the role that asphalt act as a bonding agent.

Soaked shear strength for treated asphalt soils is lower than the dry shear strength owing to the destabilization effect of water (water damage) (5).

Effect of cement and lime on stabilized sand:

Figures (6) to (7) show the effect of Portland cement and lime additive on the stability, flow and shear strength of stabilized sand respectively. These figures clearly show that adding cement and lime increase the stability and unconfined compression strength and decrease flow of stabilized soil.

When lime and Portland cement are added to natural asphalt in aging case, both serve as filler because no water is available for hydration. The additives will tend to modify the gradation of the treated soil, which is an advantage for sand dune mixes. It can be seen that stabilization with natural asphalt is more effective when cement and lime are used in case of curing in water due to the accelerated curing effect. On the other hand, Portland cement is more effective than lime in sand modification in both case of aging and curing.

The increase of lime percentage to 9% resulted in a marked drop of soaked shear strength (Fig.(6)). It is believed that this effect can be attributed to the reduction of asphalt film cover and therefore increased water damage.

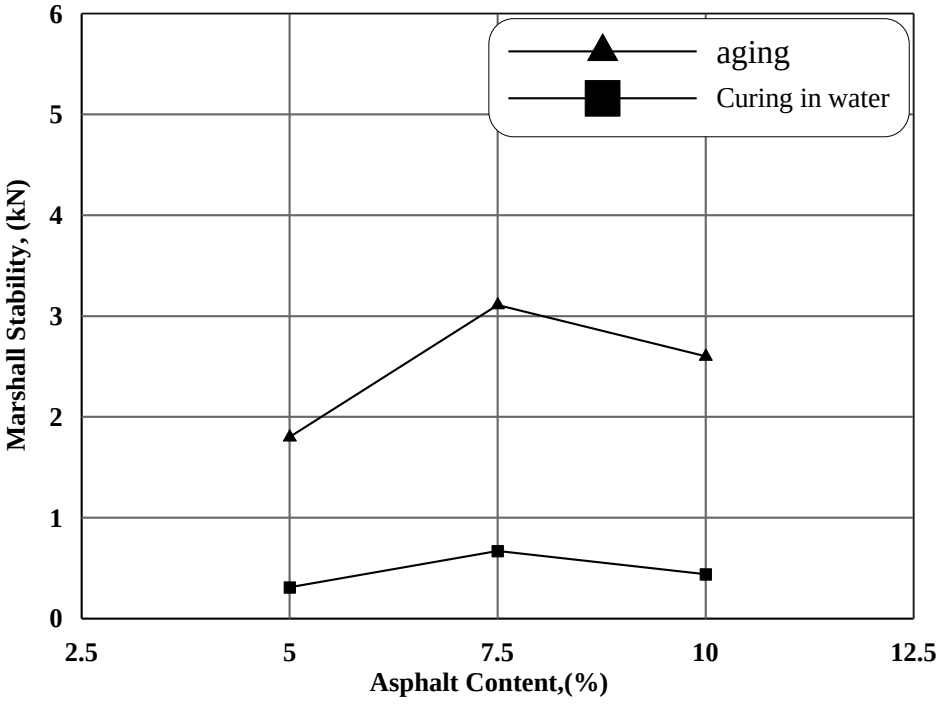

Fig. (3): Marshall Stability vs. asphalt content

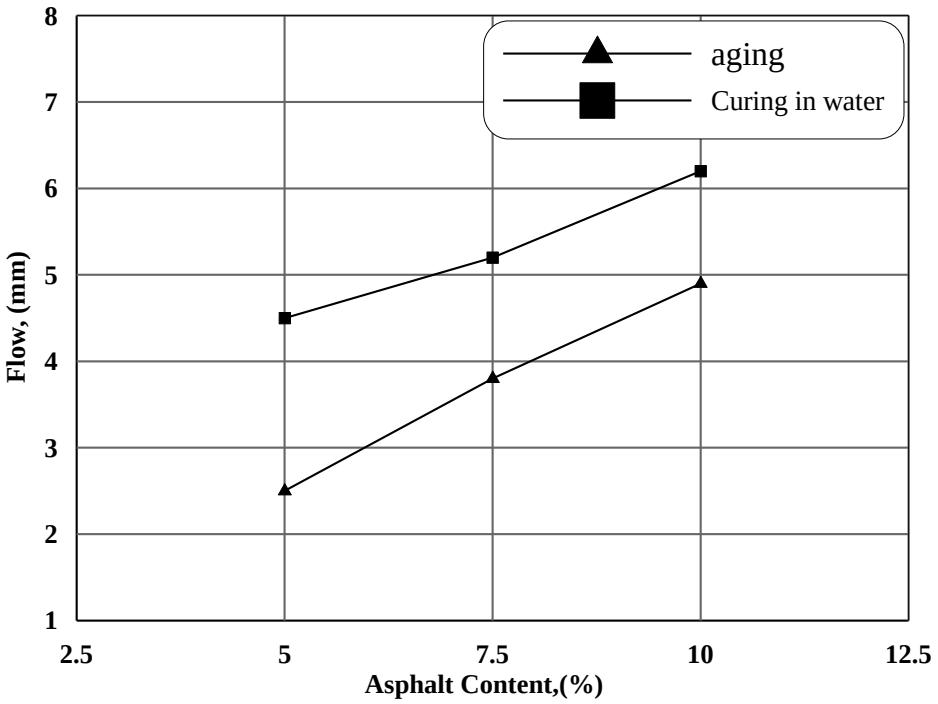

Fig. (4): Flow vs. asphalt content

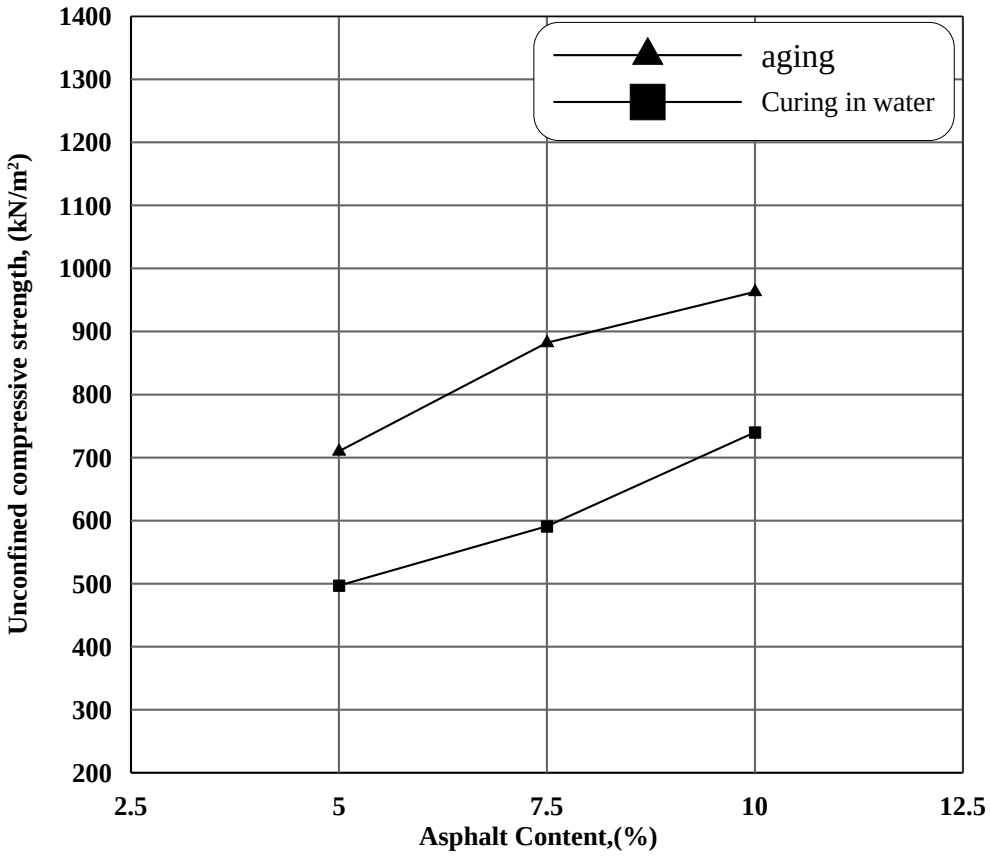

Fig. (5): Unconfined compressive strength vs. asphalt content

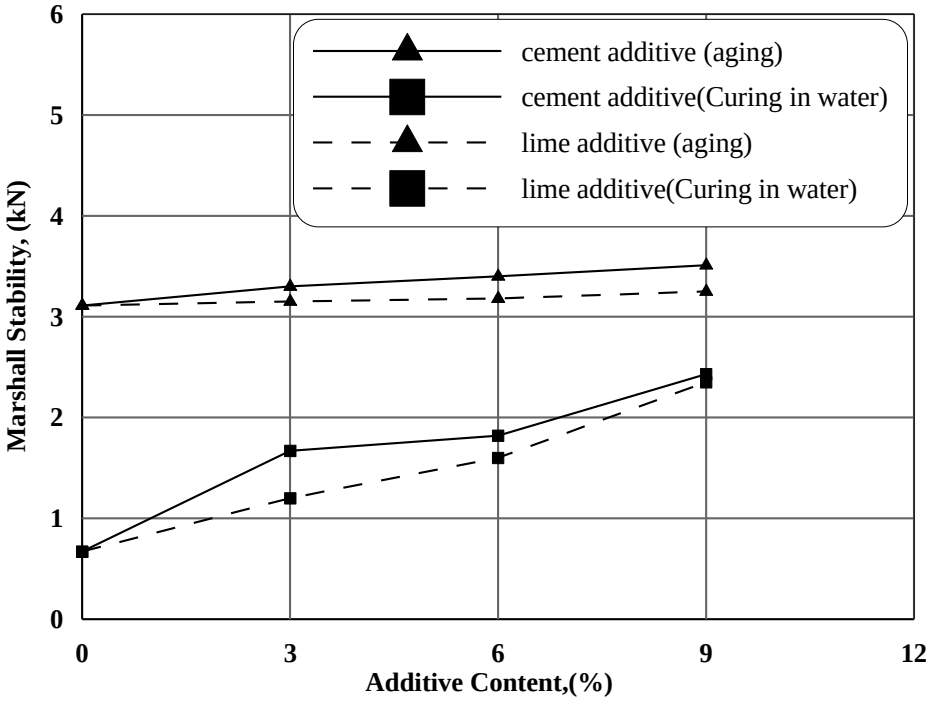

Fig. (6): Effect of additive type on Marshall Stability of specimens treated with 7.5% asphalt

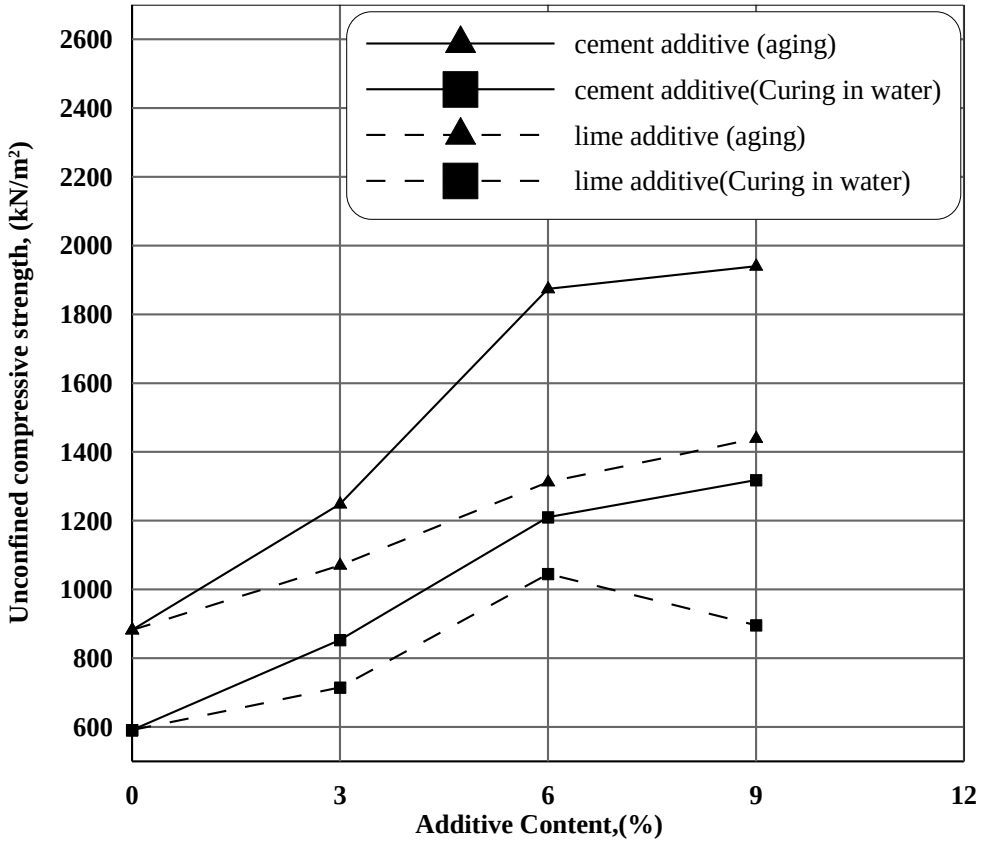

Fig. (7): Effect of additive type on unconfined compressive strength of specimens treated with 7.5% asphalt

Conclusions:

1- According to the Marshall mix design results, the optimum value of natural asphalt additive is (7.5%).

2- Adding cement and lime to sand dunes-natural asphalt mixes, increase stability and unconfined compression strength and decrease flow of stabilized soil

3- Portland cement, as an admixture, is more effective than lime when is used with natural asphalt in stabilization of sand dunes in both case of aging and curing. Furthermore, increase of lime percentage up to 9% resulted in a marked drop of soaked shear strength.

4- Utilization of natural asphalt as a productive stabilization material for sand dunes would have considerable environmental benefits, reducing land, air and water pollution.

References

1-AL-Taie, A.J. (2002), "Properties and Behavior Of Dune Sands As Construction Material", M.Sc. Thesis, Department of Civil Engineering, University of Baghdad.

2- Ahmed, N. B," Chemical Stabilization of Baiji Sand Dunes In Iraq", Qatar University Journal, Vol.15, No. 1, p.p. 109-113, 1995.

3- Al-Abdullah, S. F." An Approach In Improving The Properties Of Sand Dunes", Journal of Engineering, University of Baghdad, Vol.12, No. 4, p.p. 930-939, 2006.

4- Baghdadi, Z. A, Fatani, M. N. and Sabban, N. A," Soil Modification By Cement Kiln Dust", Journal Of Materials In Civil Engineering , Vol. 7, No.4, p.p. 218-222, 1995.

5- Terrel, R. L., Epps, J. A., Barenberg, E. J. Mitchell, J. K. and Thompson, M. R., Soil Stabilization in Pavement Structures-A User's Manual, Vol. 2, Mixture Design Consideration. Federal Highway Administration, Washington, D.C., 1984.

6- Singh, A., Nag, C.P. and Joshi, S.M." stabilization of Dune Sand With Bitumen", Indian Highway, 1979.

7- AL-Esh, M. "Materials of Building and maintenance the Roads" The first international Syrian conference of Roads, Central Company for Roads and Bridges, Damascus, Syria, 2006.

8- محمود، بشارعبد العزيز، عبد الكريم،احمد حازم ومحمد،ياسر عبد المجيد "دراسة امكانية استثمار قير العيون الكبريتية في منطقة هيت لاغراض البناء والانشاء" المجلة العراقية للهندسة المدنية ، العدد التاسع، كانون الاول ٢٠٠٧.

9- Marketing Specifications of Iraqi Petroleum Products, Ministry of Oil, Iraq,1981.

10- Al-Abdul Wahhab, H. I. and Asi, I. M., "Stabilization of a Saudi sabkha soil with liquid asphalts", Presented at World Congress on Emulsion, Paris, France, 1993.

11- Al-Abdul Wahhab H. I., "Improvement of Marl and Dune Sand for Highway Construction in Arid Areas", Budding and Environment, Vol. 32, No. 3, pp. 271-279, 1997.

12- Annual Book of ASTM Standard, Vol. 04-08, 2000.

13- Head, K.H., "Manual of Soil Laboratory Testing", Vol. 2, Pentech Press, London, 1989.