Soil Stabilization With Palm Fibers

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Abstract

This study concerns with the improvement of soils in Basrah area. Two types of soil have been selected; the first from Garmatt Ali place and the second type from Abu Al-Khasseeb place. Natural (palm) fibers are used in stabilization of these soils. These fibers were added by different percentages (0, 1, 2, and 3%) by weight of dry soil so as to improve soil properties.

The selected soil are subjected to different tests such as liquid and plastic limit, specific gravity, unconfined compressive strength, compaction test.

It was found that the addition of fibers to the soil affects compaction characteristics by decreasing maximum dry density and increasing optimum moisture content for both types of soils. The unconfined compressive strength increased with more addition of fibers .The affect of fibers content on swelling ,the swelling percent reduced especially during first days of the test.

المستخلص

تثبيت التربة باستخدام ألياف النخيل

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تهتم هذه الدراسة بتحسين ترب البصرة الرخوة، لقد تم اختيار نوعين من الترب، الأول من موقع كرمة علي والثاني من موقع أبي الخصيب. وقد تم استخدام الألياف الطبيعية المتمثلة بألياف النخيل في عملية تثبيت هذه الترب، أضيفت ألياف النخيل بنسب مختلفة (٠و١و٢و٣ بالمائة) من وزن التربة الجافة.

أظهرت الدراسة أن اضافه ألياف النخيل تحسن من مقاومة التربة، وذلك من الفحوصات التي أجريت عليها والتي شملت فحوصات مقاومة الضغط غير المحصور وفحص الرص ، أظهرت الدراسة أن نسبة محتوى التي تعطي أفضل النتائج هي ٢% من وزن التربة الجافة ثم تبدأ المقاومة بالنقصان بازدياد نسبة هذه الألياف.

كذلك أظهرت الدراسة أن اضافه ألياف النخيل إلى التربة تزيد من نسبة الرطوبة المثلى المستخرجة من منحني الرص عن التربة غير المعاملة كذلك فأن الكثافة الجافة تقل بإضافة هذه الألياف إلى التربتين.

وقد أظهرت الدراسة ان نسبة الانتفاخ تقل باستخدام ألياف النخيل وخصوصا في الأيام الأولى.

Introduction

The term soil stabilization in its widest meaning comprises any process which increases the natural strength of the soil [1], or it is the alteration of any property of a soil to improve its engineering performance [2].

Soil stabilization is usually achieved by the addition of some materials that have adequate properties to strengthen weak soils.

There are many techniques of stabilization, and there are many types of addition that can be added to the soils so as to strengthen it. Fibers are not usually used as soil stabilizer, but in this study palm fibers are introduced as a stabilizer material and its effect on engineering properties of selected soils is studied.

Soil stabilization is used to achieve one or more of the following five items [1,3,5]:-

1- Increase the strength of the soil.
2- Improve the stability of the soil to with stand the small deformations produced by loading under any weather condition.
3- Control soil permeability to prevent surface water from entering the soil.
4- Reduce frost susceptibility.
5- Reduce compressibility.

The purpose from this study is to: -

1- Determine the effect of palm on compaction characteristics (Maximum dry density and optimum moisture content) of Basrah soils.
2- Improve soil strength (unconfined compressive strength).
3-Determine the influence of palm fiber on swelling of selected soils.
4- Improve the California bearing ratio at different soil condition.

Material and Tests

1-Materials

A- Soils

Two types of soils were selected from Basrah area in which these soil has different properties. The two types are design at as follows

S_1 : From Garmatt-Ali place, and

S_2 : From Abu-Alkhaseeb place

These selected samples of soils were tested in the laboratory for:-

i) Specific gravity

ii) Sieve analysis

iii) Hydrometer

iv) Liquid and plastic limit

The grain size distribution of the two soils is shown in figure (1). The index properties of the two selected soils are shown in table (1).

B-Palm Fibers

Palm fibers are natural materials that are used in this study as a stabilizer material. It consists of long pieces with very small diameter. It this study the length of fibers were chosen approximately from 1cm to 3cm according to the mould size used in the laboratory tests. The tensile strength of individual fiber is about (0.2 kN./m^2) and the total density of palm fibers is about (0.795 g/m^3).

c- Water

Potable water was used in the preparation of specimens for all tests in this study.

2- Laboratory Tests

The selected soils (S1 and S_2) are subjected to the following tests: -

1- Specific gravity.
2- Liquid and plastic limits.
3- Grain size analysis.
4- Compaction test.
5- Unconfined compressive strength test.

Results and Discussion

1- Soil Classification

As shown in table (1), according to unified classification system, soil S_1 is (ML) and soil S_2 is (CH). This type of classification depends on what's is called plasticity chart (Casagrande's chart). According to AASHTO classification system S_1 is classified as (A-2-6), while S_2 is classified as (A-7-6).

2- Grain Size Distribution

The grain size distribution curves of the two soils are shown in figure (1). The percentages of clay particles are 5% and 7% for S_1 and S_2 respectively. Also the percentages of silt are 29% and 70% for S_1 and S_2 respectively.

3- Compaction test of treated soil

Compaction curves of treated soils with different percentage of fibers are shown in figures (2) to (5) and figure (6) to (9) show the effect of fibers on maximum dry density and optimum moisture content for both standard and modified compaction tests.

Generally, the addition of fibers causes an increase in optimum moisture content and a decrease in maximum dry density. The increase in optimum moisture content is due to ability of fibers to absorb water, therefore, the mixture requires more amount of water when treated with fibers; the decrease in maximum dry density is due to the very small unit weight of fibers as compared with the soil.

4- Unconfined Compressive Strength

The unconfined compressive strength test results are shown in figures (10) to (13) for untreated and treated soils with different percentages of fibers content by using standard and modified compaction effort.

The unconfined compressive strength increases with the addition of fibers to the soil and reached a maximum strength at 2 percent of fiber content for the two types of soil; then the strength decreases with the more addition of fibers, the increases in the strength of soils is due to present of fiber pieces that restrict soil particle movement and work as reinforcement while the decrease in the strength for high fiber percentage is due to much amount of fibers which is separate soil particles and prevent their cohesion and also is due to sliding of fiber pieces.

It can be observed from figures (10) to (13) for both types of soils S_1 and S_2, that the maximum value of unconfined compressive strength occurs at water content slightly lower than that of optimum moisture content. This behavior can be explained according to the soil structure obtain by compacting this soil.

Figure (14) and (15) show the relationship between maximum unconfined compressive strength and fibers content for standard and modified compaction efforts. The maximum strength values of soil treated with (2) percent of fibers are (550 kN./m^2) and (427 kN./m^2) for standard compaction test, and (1256 kN./m^2) and (932 kN./m^2) for modified compaction test for soils S_1 and S_2 respectively.

The increase in strength at (2) percent of fibers content for soils S_1 and S_2 compacted with standard proctor effort are (29%) and (21%) respectively, while the increase with the modified proctor effort are (51%) and (35%) for S_1 and S_2 respectively.

California Bearing Ratio(CBR)

The CBR test specimens are compacted by using modified Procter effort with optimum moisture content obtained from the same compaction test. Half of specimens were tested directly after compaction and other half are tested after 4 days.

Figure (16) and (17) show the relationship between fibers content and CBR values. The addition of fiber increases CBR and the strength reach its maximum value at 2 percent of fiber content, then the strength decreases at 3 percent of fiber content. The maximum values of CBR for treated soil with 2 percent fiber content at optimum condition are (26.6%) and (17.2%). While at soaked condition the values decrease to (17.65%) and (11.75%) for s1 and s2 respectively. this behavior is due to the same reasons that were explained in unconfined compressive strength. .

Swelling

The results of vertical swelling test are shown in Fig (18) and (19) for both types of soils, and final swell results is shown in table (5). Final swelling of untreated soil s2 .The value of swelling of s1 is (0.25%), while for s2 is (2.76). This is due to the percent of clay particles presents in soil s2, which is more than that of soil s1, therefore, the swelling will be higher. When fibers are added to the soils, swelling decreases for both types of soil. This decrease is due to the friction forces between fiber pieces and soil particles, which prevent the movement

Of soil, swelled particles. The optimum fiber percentage for s1 is (1%), while optimum percentage of s2 is (2%). The addition of fibers over optimum percentage increase is due to the large quantity of fibers, which absorb water.

Splitting tensile strength

The result of splitting tensile strength is shown in fig (20) and (21) for both types of soil. The addition of fibers increases tensile strength, the strength reached its maximum value at 2 percent of fiber content, then strength decrease with more addition of fibers. This increase in the tensile strength can be explained as follows: when vertical load applied on a soil, soil particles that in contact with fiber pieces tend to slip on fibers but friction force between particles and fibers prevents that. Fraction force converts to a tensile force on fibers and these fiber connect soil particles so that the strength increases.

Conclusion and Recommendations

Based on laboratory tests the following conclusions are obtained: -

1- The addition of palm fibers to soils decreases continuously maximum dry density and increases optimum moisture content.

2- The addition of palm fibers increases the unconfined compressive strength. The inclusion of (2%) of Faber's in the soil samples gives the maximum strength, the strength decreases with 3% of fiber content.

3 - For both optimum and soaked conditions, the California bearing ratio (CBR) increases with the addition of palm fibers, and reaches its maximum value at 2% of fiber content.

4- Swelling of compacted soil decreases with palm fiber addition, the optimum fiber content for s1 is 1% and for is s2%.

5- It is recommended to use other additives such as cement, lime and bitumen in combination with palm fiber.

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Table (1) Engineering Properties of the Investigated Soils

Designation	S_1	S_2
Location	Garmatt-Ali	Abu-Alkhasseb
Depth of Sampling (m)	0.6	0.7
LL %	40	55
P.L %	26	25
P.I %	14	30
Gas	2.72	2.66
Passing slave (0.075mm)	34	87
Unified classification system	ML	Clt
AASHTO classification system	A-2-6	A-7-6
Swelling %	6.25	2.76
MD.D (standard proctor)	17.17	16.35
OMC (standard proctor)	19.2	21.3
MDD Modified proctor	18.22	17.83
OMC Modified proctor	15.1	16.9
Colour	Red Brown	Brown

Table (2) Results of Compaction For Untreated Soils

Soil	Standard Proctor		Modified Proctor	
	OMC(%	MDD(kN/m³)	OMC(%)	MDD(kN/m³)
S_1	19.2	17.17	15.1	18.22
S_2	21.3	16.35	16.9	17.85

Table (3) Results of Standard and Modified Compaction Test

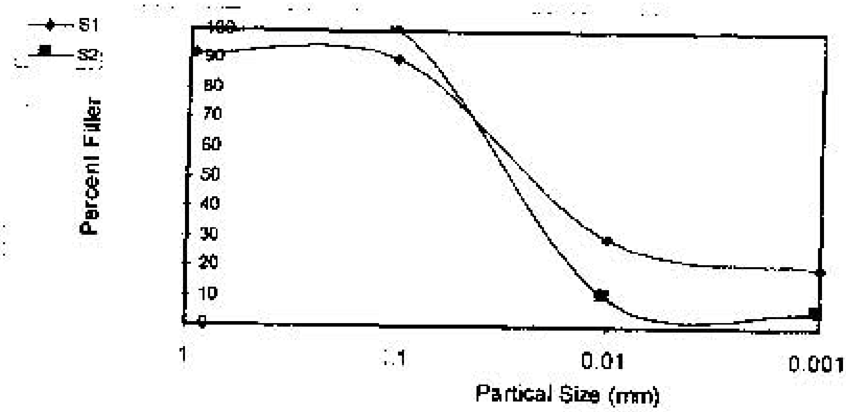
Soil	Fibers Contents (%)	Standard		Modified	
		Optimum Moisture Content(%)	Max. Dry Density - (kNm³)	Optimum Moisture Content(%)	Max. Dry Density (kN/m³)
S_1	0	19.2	171.17	15.1	18.22
	1	20	16.82	15.9	17.89
	2	21	16.27	16.7	17.66
	3	21.7	15.6	17.6	17.24
S_2	0	21.3	16.35	16.9	17.85
	1	22.5	16.02	17.9	17.48
	2	23.6	15.75	19	17.2
	3	24.7	15.26	20	16.97

Table (4) Results of Unconfined Compressive Strength For Standard and Modified Compaction Effort

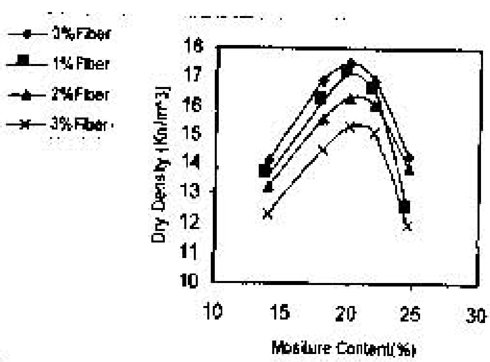
Soil	Fibers Content (%)	Standard Max. Unconfined Compression Strength (kN/m²)	Modified Max. Unconfined Compression Strength (kN/m²)
S_1	0	427	834
	1	455	949
	2	550	1256
	3	509	1093
S_2	0	354	690
	1	375	772
	2	427	932
	3	411	821

Table(5) Results of Swelling Test

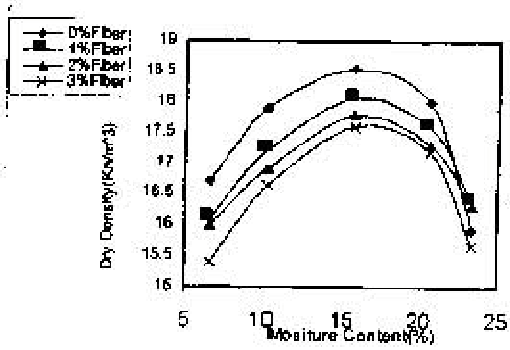
Soil	Fibers content(%)	Swelling(%)
S_1	0	0.25
	1	0.2
	2	0.5
	3	0.72
S_2	0	2.76
	1	1.52
	2	0.54
	3	0.74



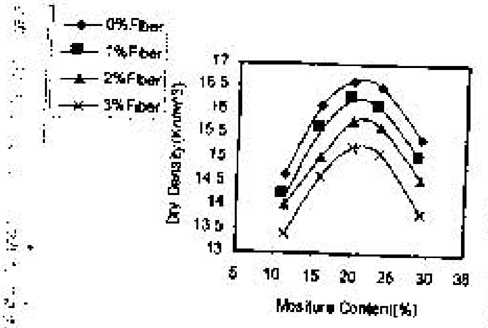
Fig(1) Partical Size Distribution



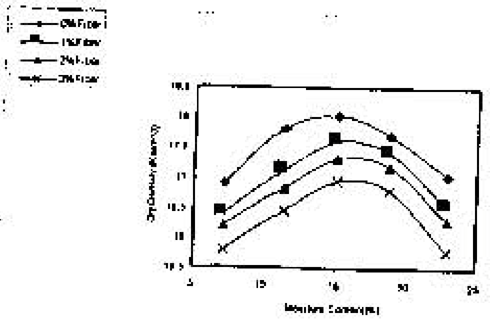
Fig(2)Standard Compaction Curves for S1



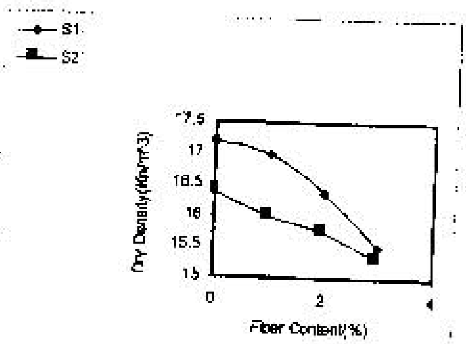
Fig(3)Modified Compaction Curves for S1



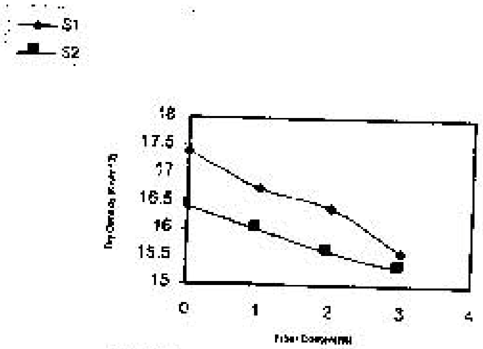
Fg(4)Standard Compaction Curves for S2



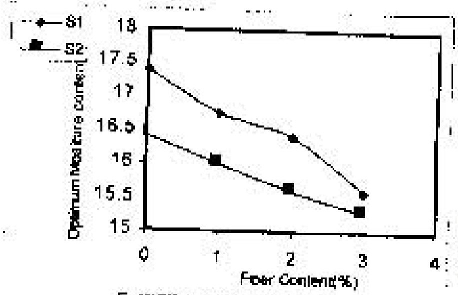
Fig(5)Modified Compaction Curves for S2



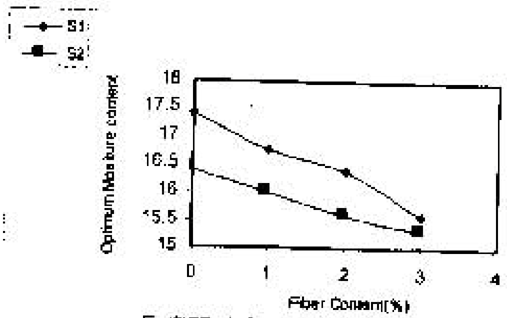
Fig(6)Effect of Fibers Content on Maximum Dry Density Using Standard Compaction Test



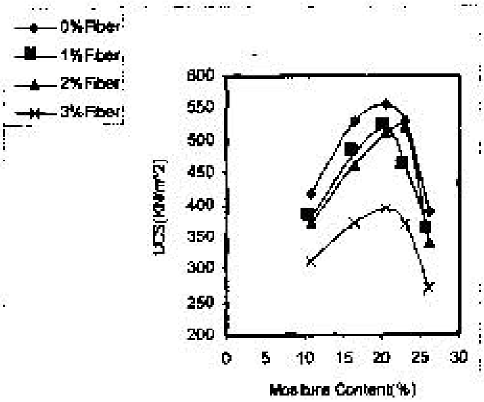
Fig(7)Effect of Fibers Content on Maximum Dry Density Using Modified Compaction Test



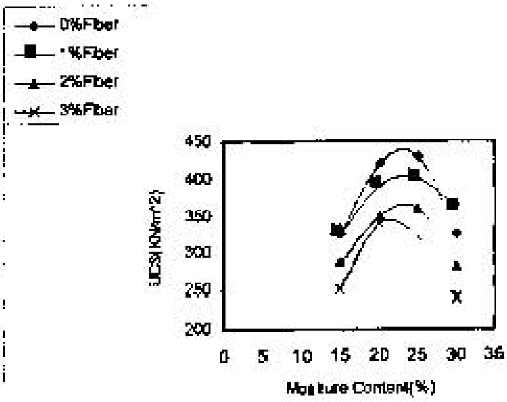
Fig(8)Effect of Fibers Content on Optimum Mositure content UsingStandard Compaction Test



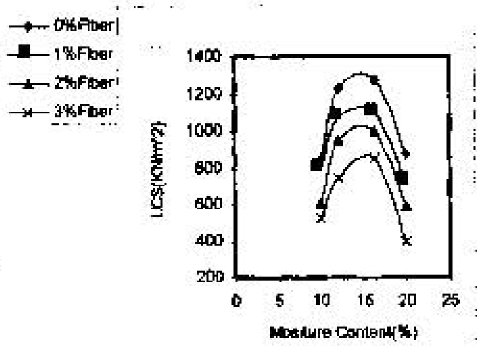
Fig(9)Effect of Fibers Content on Optimum Mositure content UsingStandard Compaction Test



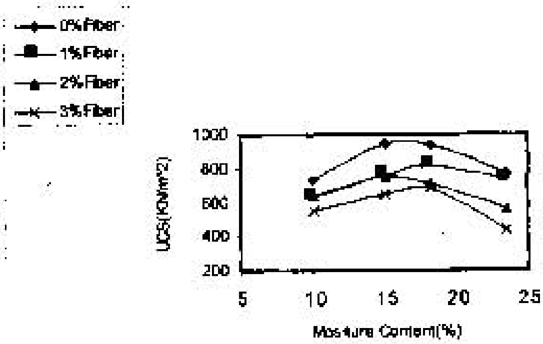
Fig(10)Mositure Content and Unconfined Compressive Strength Relationship for Soil S1 Using Standard Procter compaction Effort



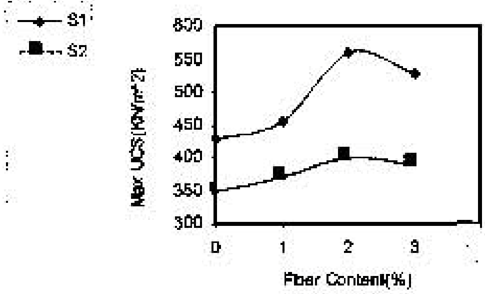
Fig(11)Mositure Content and Unconfined Compressive Strength Relationship for Soil S2 Using Standard Procter compaction Effort



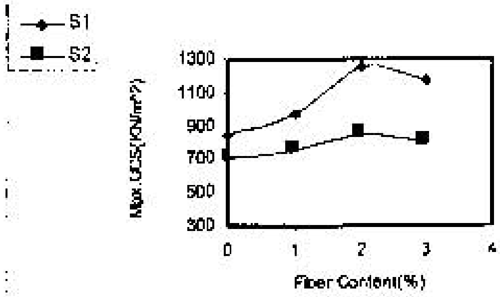
Fig(12) Mositure Content and Unconfined Compressive Strength Relationship for Soil S1 Using Modified Procter compaction Effort



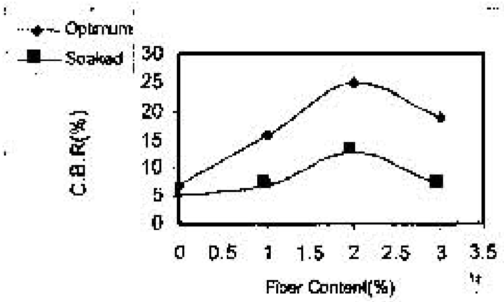
Fig(13)Mositure Content and Unconfined Compressive Strength Relationship for Soil S2 Using Standard Procter compaction Effort



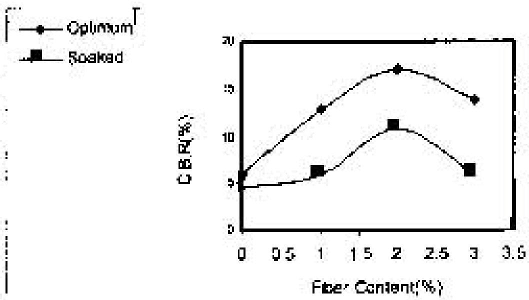
Fig(14) Results of Unconfined Compressive Strength Using Standard Compaction Effort



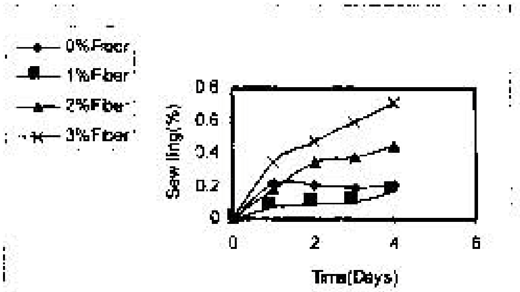
Fig(15) Results of Unconfined Compressive Strength Using Modified Compaction Effort



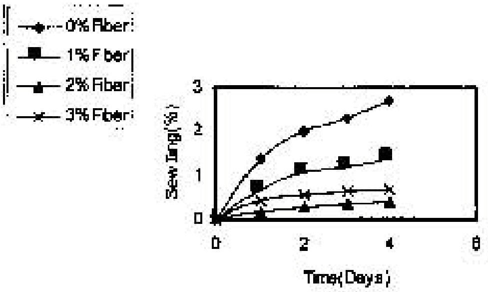
Fig(16) Results of CBR Test for S1



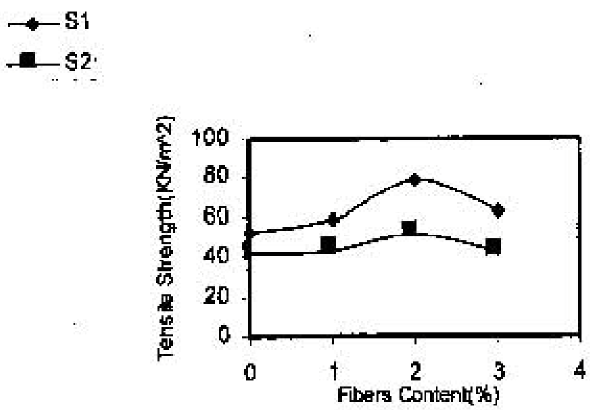
Fig(17) Results of CBR Test for S2



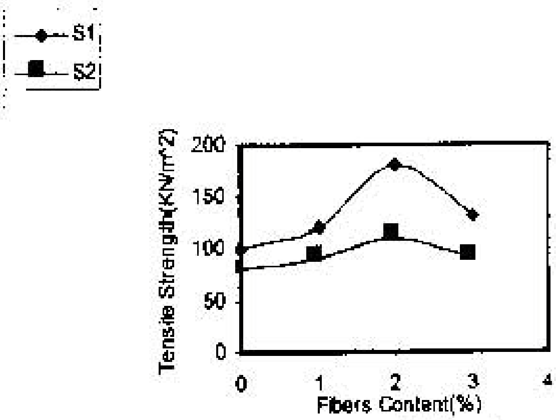
Fig(18) Sewlling Test Test for S1



Fig(19) Sewlling Test Test for S2



Fig(20)Fibars Content-Tensile Strength
Relationtship Using Standard Compaction Effort



Fig(20)Fibers Content-Tensile Strength
Relationtship Using Modified Compaction Effort