*Eng. & Tech. Journal , Vol. 31 ,Part (A), No.20 , 2013*

*1st International Conference for Geotechnical Engineering and Transportation ICGTE in2415/4/2013*

# Influence of Poypropylene Fibers on the Soil Stabilization

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## ABSTRACT

In this paper the polypropylene fiber was chosen as the additive material to know how it is effect on the soil stabilization, which it is used as additive for concret mixture; the polypropylene fiber is inert material and does not interact with water. The paper studies the addition of this material to a silty clay soil and its effect on the consistency limits, shear strength and compaction of the blended materials. The results show that there is an improvement in the shear strength only when the addition of the rate 1% and 2%from soil weight; either the effective of the consistency limit it was increasing the water content with increasing the rate of the addition material, because it have drink of water. At the compaction test it was founded that the increasing in dry density at the addition of 1% and 2% and reducing its value at the addition of 3% with increasing of water optimization.

**Keywords:** Soil Stabilization, Polypropylene Fibers, Consistency Limits, Shear Stress, Soil Compaction.

# تأثير ألياف البولي بروبلين على تثبيت التربة

**الخلاصة**

في هذا البحث، تم اختيار ألياف البولي بروبيلين كمادة مضافة لمعرفة تأثيره على تأثير على تثبيت التربة، والتي تستخدم كمضاف لخليط الخرسانة، وألياف البولي بروبلين هي مادة خاملة لا تتفاعل مع الماء. يدرس البحث إضافة هذه المادة إلى التربة الطينية الغرينية وأثرها على حدود القوام، قوة القص والرص للمواد المخلوطة. وتظهر النتائج أن هناك تحسنا في قوة القص فقط عند إضافة نسبة 1٪ و 2٪ من وزن التربة؛ إما حدود القوام الفعالة تعمل على زيادة محتوى الماء مع زيادة نسبة المواد بسبب شرب الماء. في اختبار الرص، وجدت زيادة في الكثافة الجافة عند إضافة 1٪ و 2٪ و تقل قيمتها عند إضافة 3٪ مع الزيادة المثلى للمياه.



https://doi.org/10.30684/etj.2013.83802

## INTRODUCTION

Soil stabilization, is a process that changes one or more of the properties of soil engineering and used of multiple ways to increase the strength and durability of the soil, and improve the engineering properties of the other (dry density, Permeability), and all these methods are includes in two fields:

## STABILIZATION BY MECHANICAL METHODS

To be made compaction of soil where the soil compaction by different equipment compaction and often used this method in construction of dams, earth retaining walls and roads; this method works to change the physical properties of the soil, and therefore increase the density of the soil mechanically near the soil particle closer together and thus reduce the size of the air with the survival of the volume of water constant.

## STABILIZATION BY ADDITIONS INCLUDE

### A-Stabilization by the addition of inert material

Such as mixing clay with gravel, this method is considering one of the oldest methods of the stabilization, where it helps to improve the strength of the soil and reduce the pressure and fragment.

### B- Stabilization by adding chemical material

This method is often used in soil stabilization when the mechanical methods of stabilization are insufficient or the process of replacing the undesirable soil with another good is not possible or too costly, and that most of the chemical method of stabilization is performed using the following materials:

1- Cement
2- Lime
3- Fly ash
4- Asphalt material

## PREVIOUS STUDIES IN SOIL STABILIZATION

Recently, engineers started to use different types of the fiber in soil stabilizations. These fibers are found in the market as short, discrete materials with different aspect ratio and they can be mixed randomly with the soil, as cement, lime, or other additives at different percentages. The main reason of using randomly oriented fibers is to maintain strength isotropy and the lack of potential weak planes that may develop parallel to oriented reinforcement [1, 2].

Fatani *et al*. (1991) [3] studied the effect of both aligned and randomly oriented metallic fibers on silty sand. It was found that mixing fibers with silty sand soil will increase the peak strength and residual strength 100% and 300% respectively over the untreated soil. Ziegler *et al*.(1998)[4] studied the effect of short polymeric fiber on crack behavior of clay subjected to drying and wetting conditions. He concluded that the addition of fibers to the clay soil is very effective in reducing the amount of

Desiccation cracking and increasing the tensile strength. Freitag (1986) [5] mixed the fiber with clayey soil and showed that addition of fiber will increase the strength and ductility than plain clayey soil. the addition of nylon fiber by Kumar and Tabor (2003) [6] resulted in significant increase in the residual strength of silty clay soil. Atton and Al-Tamimi (2010) [7] study the effect of two types of polypropylene fibers on shear strength parameters of sandy soil. its results showed that the shear strength of the sand increasing with increasing the flexible flat profile fibers content .also it noticed that by increasing the aspect ratio (L/D)of the flexible flat profile the angle of internal friction and the shear strength increased.

The polypropylene fiber is an inert material but have a drink of water, and the Table (1) shows its properties.

## THE SOIL USED

It is used in this research silty clay soil with low plasticity (CL) that have specific gravity (2.65) and consistency limit (30, 40, 10) for both limits plasticity (PL) and liquidity (LL) and plasticity index(PI) respectively.

## LABORATORY TESTS

For the purpose of assessing the effect of addition of polypropylene fiber on the soil is a laboratory tests described below:

### -Atterberg limits

This tests were carried out according to (ASTM 423-66) for liquid limit and (ASTM D424-59) for plastic limit.

### -Unconfined Compressive Strength test

This test was carried out according to (ASTM 2166-66), after mixing the specific ratio of the polypropylene fiber material with soil and then compacted the mixture by standard Proctor test, and then prepare testing form.

### -Soil Compaction test

This test was carried out by standard Procter method according to (ASTM D698-70 and D1557-70).

### Ratio of additives

Are conducting laboratory tests after the addition of percentages 1%, 2% and 3% of polypropylene fiber material of the weight of dry soil and conduct the same tests without soil additives for the purpose of comparative results.

Not used in this research more percent of this material as expensive if used in a process, not an experiment.

## RESULTS AND DISCUSSION

### -Consistency limits test

Figure (1) shows the relation between the ratios of the additive material with Atterberg limits (LL and PL), it is shown that the increasing in the water content with increased the ratio of polypropylene fiber, this is due to the property of polypropylene

Fiber in the absorption of water added so it needs to mix into the water more accessible to the extent of liquidity and plasticity limits.

Table (2) shows the ratio between the plasticity index (PI) and classifying the soil according its plasticity [8], from the table notice that the soil used its fill in the third part, while the soil at 1%, 2% and 3% f ill in the fourth part, the result of the scan rate of 2% approach to the specifications required to monitor the basis of soil layer for roads and airports under the specifications in the Guide to the U.S Air force (Military Soils Engineering, FM 5-410)(36-3TM5-330/Air force manual (MFA) [9].

**-Unconfined Compressive Strength**

Figure (2) shows the relation between the ratio of additive material and unconfined compressive strength (qu), the figure shown that the increasing in (qu) with increasing in the rate in 1% and 2% from the polypropylene fiber; while at 3% decreasing accruing in qu. This is resulted because the polypropylene fiber at 1% and 2% acts as a reinforcing material for the soil; therefore it is strengthening the soil, but at the 3%

the adding material is working on slipping the particle of soil on the other it; therefore weakening the soil.

**-Compaction Soil**

Figure (4) shows the relation between the water content ($w_c$%) and dry density ($\gamma_d$) for the soil without adding and the soil with adding material. Figure (5) shown the relation between the adding materials with maximum dry density. its notice for this figure increase in dry density with increase in adding material until the rate of 3% from the adding material decreasing in dry density , but at the same time there is increasing in optimum water content the three rate as shown in Figure (6).

It can be explain this increasing in $\gamma_d)_{max.}$ with optimum water content at 1% and 2%, the adding not down to fill the air voids between the soil particle and this working to increasing the density of mixture and at the same time this particle will needed more quantity of water to lubricated the surface for best compaction but at 3% the polypropylene fiber fill all air voids between the particle and more amount of this material working to slip this particle on anther it, therefore not need more power to compact.

## CONCLUSIONS

1. Increasing in plastic and liquid limits at the increasing in the rate of polypropylene fiber.
2. Increasing in unconfined compressive strength at the rate 1% and 2% from the polypropylene fiber; while at 3% decreasing accruing in (qu) decreses.
3. Economically, when used the rate 1% and 2% from this additives, it's work to reduced the amount of the soil that used in the retaining soil , to increasing the shearing force which it is help to increasing the rate of the required slop to stapling
4. Increasing in the dry density at increasing the rate of 1% and 2% and the rate of improvement reach to the 9% and 41%, respectively. This work by this way instate of using compaction equipment which that needing to large power with large cost.

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**Table (1) properties of polypropylene fiber.**

| Property | Polypropylene |
|---|---|
| Unit weight (gr/cm³) | 0.9-0.91 |
| Reaction with water | Hydrophobic |
| Tensile strength (MPa) | 300-400 |
| Elongation at break (%) | 100-600 |
| Melting point(C°) | 175 |
| Thermal conductivity (W/m/K) | 0.12 |
| Length (mm) | 6 |

**Table (2) the Relation between the Plasticity Indexs and Classifying the soil.**

| | Plasticity index | Classifying of the soil |
|---|---|---|
| 1 | Soil not plastic(elastic) | 0 |
| 2 | Soil elastic to plastic | 1-5 |
| 3 | Soil with low plasticity | 5-10 |
| 4 | Soil with Medium plasticity | 10-20 |
| 5 | Soil with high plasticity | 20-40 |
| 6 | Soil very high plasticity | More than 50 |

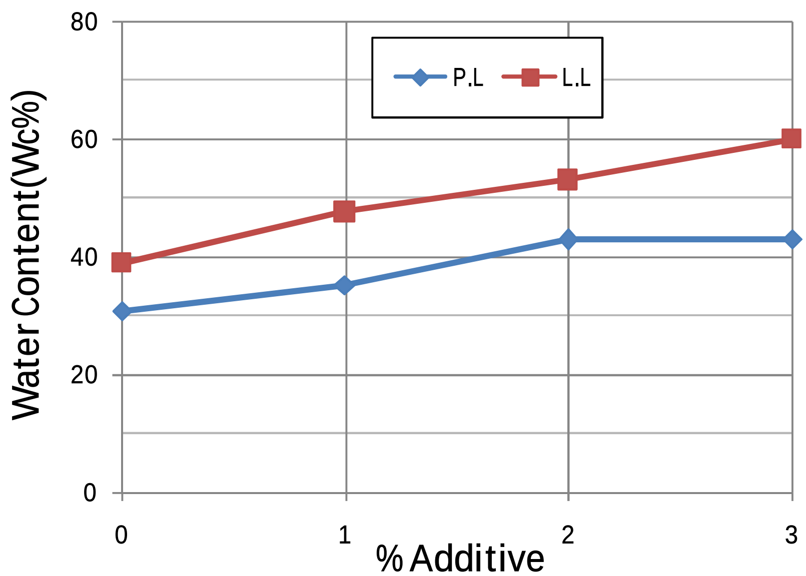


**Figure (1) the Relation between the Additive Materials and Liquid limit ,Plastic Limit.**

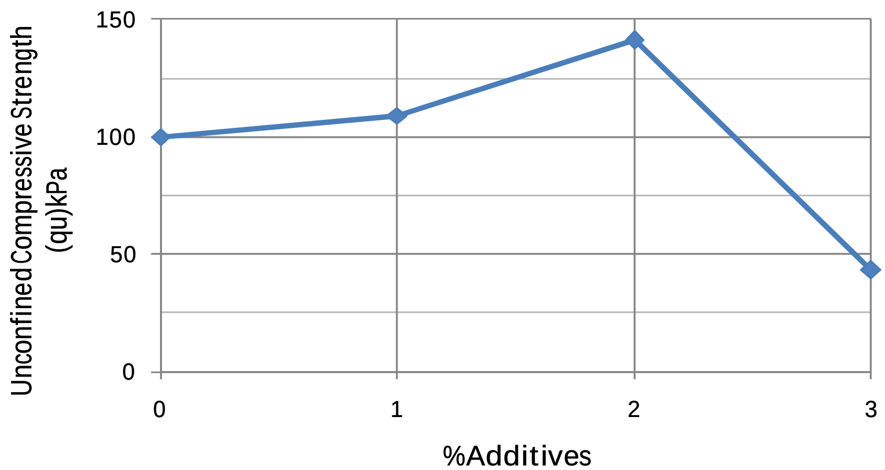


**Figure (2) The Relation between the Additive material and Unconfined Compressive Strength ($q_u$).**

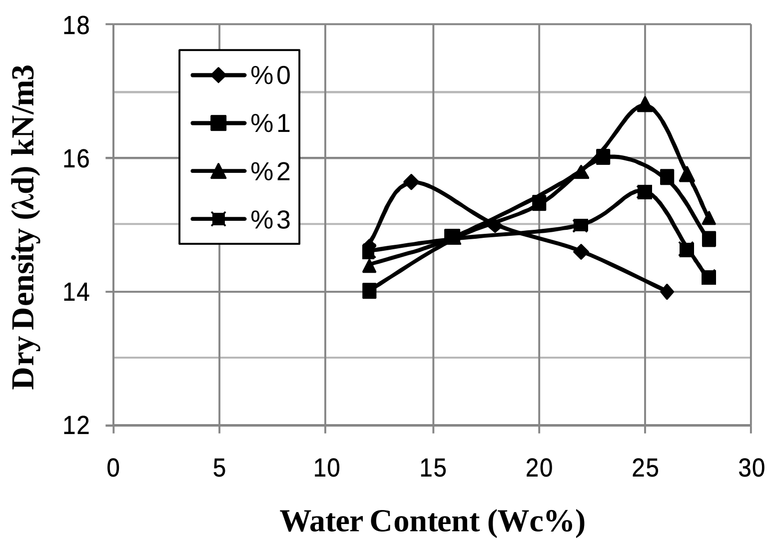

**Figure (3) the relation between Water Content and Dry Density for different Additive material.**

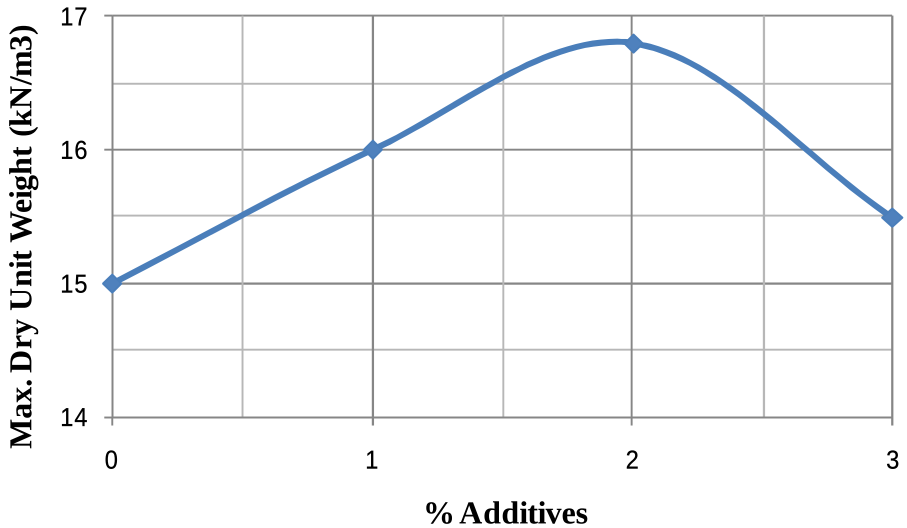


**Figure (4) The Relation between Additive material and Max. Dry UnitWeight.**

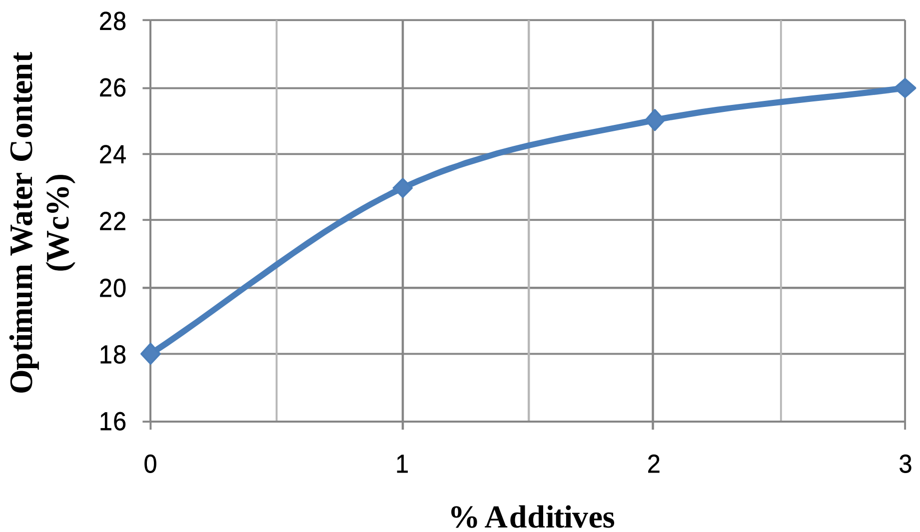

**Figure (5) the relation between Additive material and Optimum Water Content.**

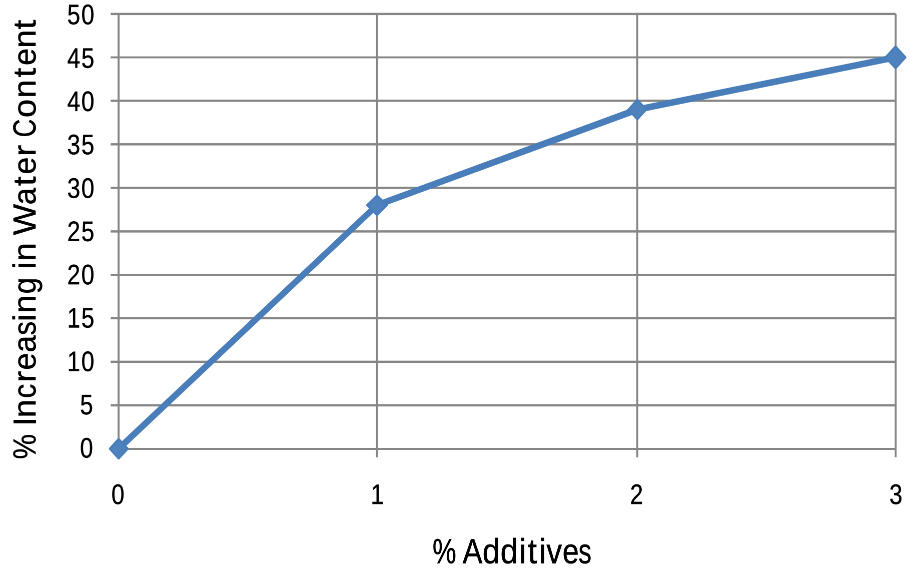


**Figure (6) the Relation between the Additive Material and the Rate in the increasing in water content.**