# Investigation of the effect of Polypropylene Fibers on compression strength and tensile strength of organic soil stabilized with lime and Xanthan-Gum bio-polymer

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## ABSTRACT

**The presence of organic matter in soil reduces its compressive and shear strength. It is, therefore, not suitable for construction projects. Soil strength can be enhanced by various methods. Stabilization and reinforcement are two common ways of improving soil strength parameters. In this study, the effect of polypropylene fibers on stabilized soil was investigated. For this purpose, lime and xanthan gum biopolymer were used as stabilizers, and soil was reinforced with polypropylene fibers. The experiments were performed using 1 and 3% lime, 1 and 1.5% xanthan gum biopolymer and 0.5% polypropylene fibers (by dry weight). To investigate the effect of these materials on soil strength, uniaxial compression strength and indirect tensile strength tests were conducted. The processing time of the samples was 7 and 21 days. The results showed that the addition of lime, xanthan gum biopolymer and polypropylene fibers can increase the compression strength of soil. Increasing the processing time can also increase the strength of stabilized soil, and addition of fibers leads to the improvement of soil ductility. The maximum tensile strength was observed in the sample stabilized with xanthan gum biopolymer. In the soil sample with 1% lime, the addition of fibers could increase the soil tensile strength. The results suggest that soil strength parameters can considerably be improved if xanthan gum is replaced with lime. In addition, this material is environment-friendly.**

## KEYWORDS

**Organic soil, Lime, Xanthan gum biopolymer, Polypropylene Fibers, Compression and tensile strength**

## 1.Introduction

Soils containing a high percentage of organic matter are not suitable for road construction projects. This is due to the low shear strength and high compressibility of those types of soil. An increased percentage of organic matter can decrease soil resistance and pH [1]. One of the previous methods of constructing roads on organic soil beds was soil replacement or preloading to improve soil engineering parameters [2]. The chemical stabilization of soil using traditional materials such as lime, cement, and fly ash [2] or new materials such as polymers and biopolymers is another option to improve the resistance parameters of different soil types [3]. Increasing the bearing capacity of soil makes it possible to use it in road construction projects. Xanthan gum biopolymer increases soil compressive strength, and an increase in the curing time / raises its resistance [4, 5].

Synthetic fibers include polypropylene, polyester, polyethylene, glass and polyvinyl alcohol fibers [6]. The addition of these materials to soil can generally increase its compressive and shear strengths [6, 7].

In this study, lime stabilizers, xanthan gum biopolymer and yarn waste fibers have been used as reinforcing materials of polypropylene to improve the resistance parameters of organic soil. The evaluation of compressive and tensile strengths was conducted for organic soil samples a) stabilized with lime and xanthan gum, b) simultaneous stabilized and reinforced with lime + fibers and xanthan gum, and c) stabilized and reinforced with lime + fibers and xanthan gum + fibers. Then, the samples were compared after 7 and 21 days of curing.

## 2.Methodology

The soil used in this study was an organic type of soil containing 67-69.1% organic matter. Lime, xanthan gum biopolymer and polypropylene BCF waste fibers were used to optimize the soil features. In terms of dry weights, 1% and 3% w/w of lime, 1.5% w/w of biopolymer and 0.5% w/w of fibers served the purpose. Tables 1-3 indicate the features of soil, xanthan gum and fibers respectively.

## 3.Result and Discussion

Addition of lime, xanthan gum and fibers to organic soil increased its compressive and tensile strengths. Addition of fibers to the soil stabilized with lime and xanthan gum increased the soil flexibility. Figure1 and 2 indicates the effect of adding fibers on the compressive strength of the soil stabilized with lime and xanthan gum in a 7-day curing time, respectively.

Increasing the curing time led to an increase in the compressive strength of the specimens, the results of which are indicated in Table 4. Table 5 indicates the tensile strengths of the specimens after 7 and 21 days of curing. Increasing the curing time also increased the tensile strength. The addition of fibers to the soil stabilized with 1% lime improved its tensile strength. The findings of this study on the enhancement of the compressive strength of the soil stabilized with lime and xanthan gum are in line with the results of previous research [4, 5, 8, 9].

**Table 1. Features of the organic soil used in the study**

| Feature | Value |
|---|---|
| Natural moisture percentage | 262-328 |
| The ratio of the initial pores | 5.8 |
| Specific density | 2.11 |
| Percentage of organic matter | 67-69.2 |
| Ash rate | 21-25 |
| pH | 6.5 |
| Maximum dry density (gr/cm$^3$) | 1.13 |
| Percentage of optimum moisture | 38.89 |

**Table 2. Technical properties of xanthan gum**

| Feature | Unit |
|---|---|
| Physical features | White or light yellow powder |
| Sieved 200(%) | More than 92 |
| Sieved 100 (%) | 100 |
| Viscosity | 1200-1700 |
| Weigh loss due to drying (%) | Less than 15 |
| pH | 6-8 |
| Ash (%) | Less than 16 |

**Table 3. Properties of BCF fibers**

| Property | Value | Unit |
|---|---|---|
| Density | 0.91 | ( gr/cm$^3$) |
| Diameter | 45 | μm |
| Length | 1-2 | cm |
| Tensile strength | 100 | MPa |

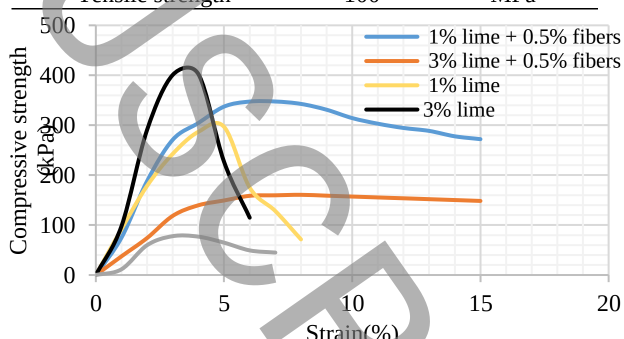


**Fig. 1. The effect of BCF waste polypropylene fibers on the compressive strength of the soil stabilized with lime in a 7-day curing time (the optimum moisture from the compaction test)**

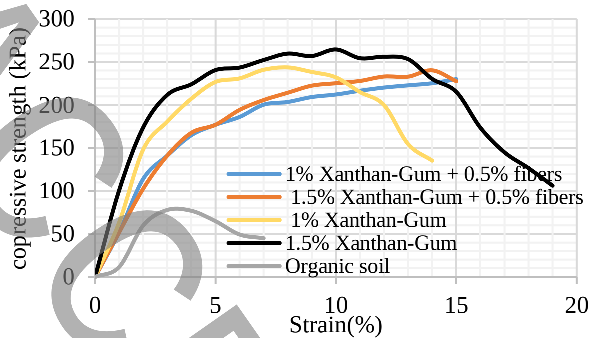


**Fig. 2. The effect of BCF waste polypropylene fibers on the compressive strength of the soil stabilized with xanthan gum in a 7-day curing time (the optimum moisture from the compaction test)**

**Table 4. The effect of increased curing time on compressive strength**

| Percentage of materials added | 7-day compressive strength | 21-day compressive strength |
|---|---|---|
| 1% lime | 296.7284 | 420.2116 |
| 3% lime | 402.2857 | 430.2222 |
| 1% xanthan gum | 243.6296 | 322.1429 |
| 1.5% xanthan gum | 264.5238 | 426.9048 |
| 1% lime + 0.5% fiber | 347.46 | 487.0935 |
| 3% lime + 0.5% fiber | 160.6186 | 246.0395 |
| 1% xanthan gum + 0.5% fiber | 230.0164 | 535.5119 |
| 1.5% xanthan gum + 0.5% fiber | 240.2296 | 333.8947 |

**Table 5. The effect of increased curing time along with the addition of fibers on tensile strength**

| Percentage of materials added | 7-day tensile strength | 21-day tensile strength |
|---|---|---|
| 1% lime | 46.07117 | 56.20682 |
| 3% lime | 49 | 59 |
| 1% xanthan gum | 60.81394 | 78.7817 |
| 1.5% xanthan gum | 66.80319 | 85.69237 |
| 1% lime + 0.5% fiber | 58.04967 | 82.9281 |
| 3% lime + 0.5% fiber | 24.87843 | 38.69978 |
| 1% xanthan gum + 0.5% fiber | 41.46405 | 58.04967 |
| 1.5% xanthan gum + 0.5% fiber | 49.75686 | 58.04967 |

## 4.Conclusion

Stabilization and reinforcement are two common methods to improve soil engineering parameters in civil projects. The potential improvement of tensile and compressive strengths of organic soil was examined in the present study. Accordingly, lime and xanthan gum were used as stabilizers while polypropylene fibers were employed as reinforcing elements. The results indicated that Lime, waste fibers of polypropylene yarn and xanthan gum biopolymer can each increase the compressive strength of soil alone. In soil stabilized with fibers, the application of a vertical force among soil particles can lead to cohesion, and the sum of this cohesion and friction among the soil particles reinforces the tensile stress in the fibers and increases the compressive strength. An increase in the lime percentage can enhance soil resistance due to improved soil particle reactivity as a result of the increase in soil calcium and hydroxide. The reactions between calcium ions and soil particles increase the strength and the cementation of organic soil stabilized with lime. Addition of xanthan gum to soil also increases the adhesion of its particles, thereby increasing its strength.

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