Effect of different fiber combinations on density and unrestricted compressive strength of clay

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ABSTRACT

In recent years, a lot of research has been done on soil reinforced with different fibers. However, in most of these studies, one type of fiber has been used and less attention has been paid to the problems of combining different fibers. Also, the use of waste fibers has been less considered economically and environmentally. Therefore, in this study, the shear strength of clay has been investigated using 5 types of fibers including: industrial steel, scrap steel, glass, polypropylene and straw individually and in combination. The research process is that first a control design is prepared from fiber-free soil. Then, soil samples were prepared with the mentioned fibers individually with the values of 0.5, 0.75 and 1%. And in the third stage, samples of soil with fibers, in dual composition including: industrial steel and glass, industrial steel and polypropylene, glass and polypropylene, scrap steel and straw with weight percentages (0.25 and 0.75), (0.5 and 0.5) and (0.75 and 0.25), respectively. Finally, the maximum specific gravity and uniaxial compressive strength of all designs have been studied and compared.

The results of this study showed that among the samples made with one type of fiber, glass with a value of 1%, the highest specific gravity and compressive strength, and among binary compounds, a combination of industrial steel and glass with a value of (0.75 0.25%), the highest specific gravity and with the amount (0.25 and 0.75%), the highest compressive strength is obtained.

KEYWORDS

Clay, industrial steel fibers, glass fibers, uniaxial compressive strength, dual composition

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1. Introduction

Soil has always been used by humans as a building material, but due to insufficient tensile strength and weak shear strength, designers have always had to use physical processes (such as compaction and drainage) and chemical processes (such as stabilization) or Increase this resistance by placing resistant elements (weapons). The issue of reinforced soil was first scientifically addressed by the French engineer and architect Henri Vidal. Vidal defined reinforced soil as a composite material of soil and reinforcing elements. In this composite system, the soil grains are responsible for withstanding the compressive forces and the reinforcement element increases the shear strength of the soil by withstanding tensile stresses [1].

In recent years, research has been conducted on fiber-reinforced soils: Kaoshiket has investigated soil bearing capacity (CBR) on soils reinforced with waste fibers. In this study, four different percentages of fibers with values of 0.3, 0.4, 0.5 and 0.6 have been used and it has been concluded that soil bearing capacity with 0.4% of fibers has the highest efficiency [2]. Hosseini, in his research, using LFRC fibers, which also insulate sound, moisture and heat, has achieved a kind of light soil with high resistance for use in rural houses to deal with earthquakes, as well as for the restoration of ancient houses. The test results show that by adding 0.75% of LFRC fibers to the soil, the desired strength and goal can be achieved [3]. Oliveira, in his research used coconut fibers as natural and cheap fibers with 0.5%, 1 and 2% as soil reinforcers and investigated the geotechnical behavior of reinforced soils. The results indicate that by increasing the percentage of fibers to 1%, it has improved soil properties [4].

In most of these studies, one type of fiber has been used and less has been done on the effect of combining several fibers. The use of waste fibers has also received less economic and environmental attention.

2. Methodology

In this research, the geotechnical properties of clay including unit weight by volume, unlimited compressive strength of soil and shear strength using 5 types of fibers including: industrial steel, scrap steel, glass, polypropylene and straw have been investigated individually and in combination. First, a control design is prepared from fiber-free soil. Then, soil samples were prepared with the mentioned fibers individually with the values of 0.5, 0.75 and 1%. And in the third stage, samples of soil with fibers, in the form of dual composition including: industrial steel and glass, industrial steel and polypropylene, glass and polypropylene, scrap steel and straw with weight percentages (0.25 and 0.75), (0.5 and 0.5) and (0.75 and 0.25), prepared. Finally, the density and uniaxial compressive strength of all designs have been evaluated and compared according to ASTM D698 [5] and ASTM D2166 [6] standards.

2. Discussion and Results

In Figures 1 and 2, the results of density test, in Figures 3 and 4, the results of optimal humidity and in Figures 5 and 6, the results of compressive strength of reinforced soil with one type of fiber and the combination of two types of fibers with different percentages are presented:

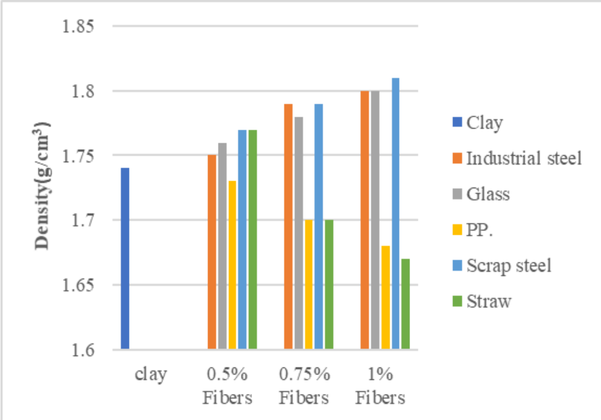

Fig. 1: Graph of density of soil that combined with five kind of fibers and with different percentages individually

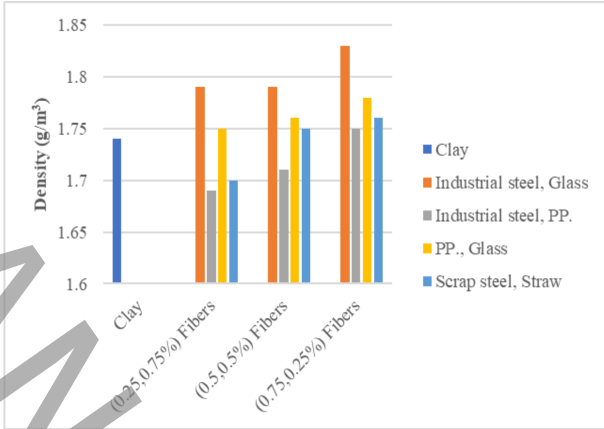

Fig. 2: Graph of density of soil combined with fibers in pairs and with different percentages

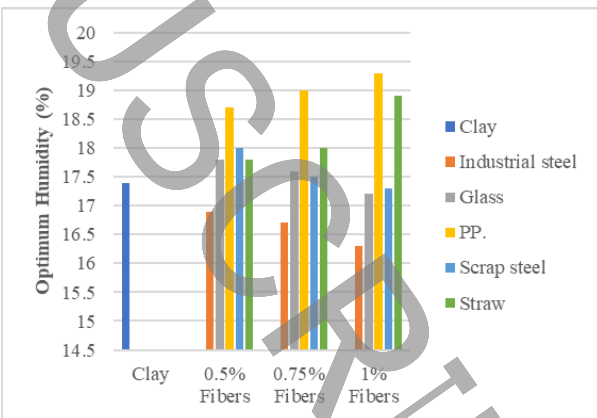

Fig. 3: Diagram of the optimal humidity of soil composite

designs with one kind of fibers and with different percentages

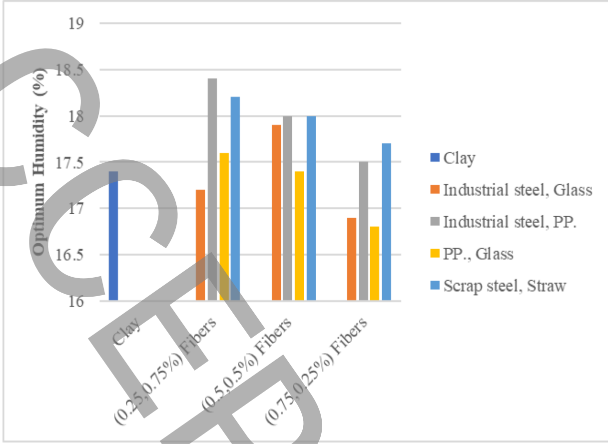

Fig. 4: Graph of optimal humidity of soil combined with fibers in pairs and with different percentages

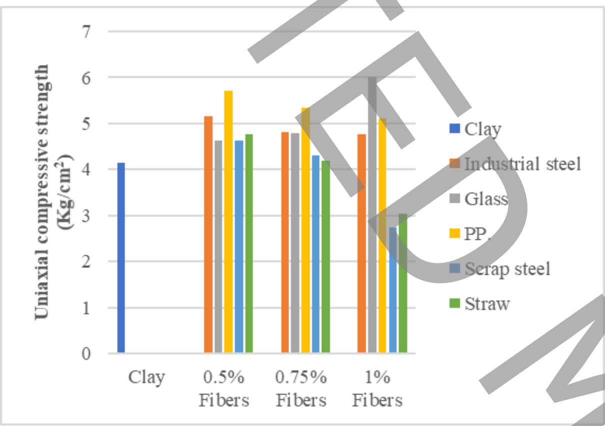

Fig. 5: Uniaxial compressive strength diagram of soil that combined with five kind of fibers and with different percentages individually

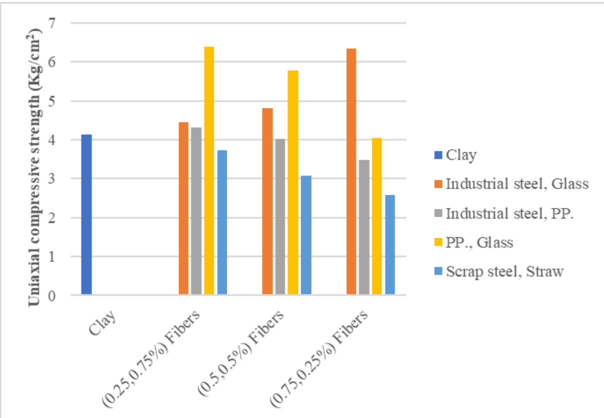

Fig. 6: Diagram of uniaxial compressive strength of soil combined with five kind of fibers and with different percentages as a pairs compound

3. Conclusions

In general, the following can be concluded from the data of this research:

a) The addition of fibers of industrial steel, scrap steel and glass has increased by about 4% and the addition of polypropylene and straw fibers has increased by about 1% by density of soil.

b) The addition of fibers of industrial steel and scrap steel, by 30%, glass fibers 45% and polypropylene and straw fibers 40%, has increased the compressive strength of the soil.

c) By comparing the results between fibers in single compounds, it can be concluded that the performance of glass fibers has been better than other fibers in improving soil condition. On the other hand, the use of polypropylene fibers and to some extent straw fibers has increased the ductility and softness of reinforced soil, which can be used in the field of repair, restoration and also the construction of clay bricks.

d) In the composition part, depending on the use of fibers in each composition, different results have been obtained. Thus, in the compounds used in glass fibers, the compressive strength, in the compounds used in steel fibers, the density, and in the compounds used in polypropylene and straw, the optimum humidity and ductility increased.

e) In general, the performance of industrial steel, polypropylene and glass has been better than scrap steel and straw. And this shows that synthetic fibers are of higher quality and its use is superior to other fibers. However, the use of waste and plant fibers is economically and environmentally justifiable and appropriate in projects such as restoration of archeological and historical monuments, temporary embankments, access roads, foundation of low importance structures and similar cases.

f) The use of more fiber combinations (triplets and more) is questionable both in terms of use and functionality and requires further research.

4. References

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