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Stabilization of the Soil Utilizing Polypropylene Fiber

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ABSTRACT

The primary purpose of this research is to investigate the use of waste fibre composites in round improvement and to assess the efficacy of refuse polypropylene fibres on the shear strength of unsaturated soil. Both of these objectives will be accomplished through the course of this investigation. Stabilization is necessary for this soil in order to strengthen its strength and durability and to stop the soil from eroding. First comes the evaluation of the unconfined compressive strength as well as the proctor test. After that, a battery of Proctor and UCS tests are carried out in order to determine whether or not the incorporation of fibre into soil improves the strength properties of the soil. The findings have been analysed and interpreted in terms of the stress-strain behaviour, the fluctuation of failure strain-stress, the influence of fibre content, and other strength characteristics. This study demonstrates that using polypropylene fibre in varying percentages for the aim of boosting soil properties is beneficial because it represents a major improved performance in both the compressive and shear strengths of the soil. As a result, the use of polypropylene fibre in these percentages is advantageous. The use of genetic programming to construct models on the basis of the data that was measured. The explicit GP model that was developed will be helpful in determining the optimal input values that will lead to the production of safe and robust bearing stratum.

Keywords: *Unsaturated Soil; Polypropylene (PP) fiber; Shear Strength; Compressive Strength; Proctor Test; UCS Test.*

1.0 Introduction

In these modern times, the practise of employing waste material in soil stabilisation or hardening the soil is becoming more commonplace all over the globe.

The increased generation of garbage, such as fly ash, plastics, and rice husk ash, which not only creates risks but also difficulties with deposition, is the primary cause for this trend. In this particular project, we are going to talk about the process of soil stabilisation by using polypropylene fibres that have been collected from discarded materials and then spreading them out in a random pattern. The foundation of any land-based construction is an essential component, and it must be robust in order to sustain the whole of the structure. The surrounding soil plays a very important part in determining the overall strength of the foundation of the building. Therefore, the procedure of stabilising soil helps to produce the appropriate qualities of a soil that are needed for the building job that is being done. As a result of the high cost involved in completely replacing poor quality soil, stability of the soil is the solution that should be sought for in situations like these.

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- It enhances the stability of the ground, which results in an increase in the bearing capacity of the soil.
- Instead of going with a deep foundation or raft foundation, it is more cost and energy efficient to raise the bearing capacity of the soil. This is true both in terms of the cost of the project as well as the energy required to complete it.
- Additionally, it is used in the process of enhancing the soil's stability in sloped areas and other similar locations. It is possible to utilise soil stabilisation in order to minimise soil erosion as well as the development of dust, which is a very important benefit, particularly when the weather is dry and arid.

In today's world, many distinct approaches to soil stabilisation are used, including steel wire reinforcement, geosynthetic reinforcement, the addition of lime, and the implementation of fibres in a random pattern into the soil.

Polypropylene (PP) fibres are favoured because they are readily available, possess the desirable properties, and are long-lasting. The micro-mechanical interaction behaviour between soil particle and reinforcing polypropylene fibres was studied in order to study PP's superior resistance to abrasion, chemicals, and biological entities. Within the scope of this investigation, we also made use of genetic programming (GP) to create models for estimating the unconfined compressive strength (UCS) of polypropylene-stabilized cohesive soils.

2.0 Materials

2.1 Soil sample

Table 1: Engineering Properties of Soil

Properties	Typical Values
IS Classification	CI
Plastic Limit	22%
Liquid Limit	47%
Plasticity Index (Ip)	25%
Specific Gravity (Gs)	2.59

Reinforcement: Short Polypropylene (PP) fiber.

Table 2: Index and Strength Parameters of PP Fiber

Behaviour Parameters	Values
Fiber Type	Single Fiber
Unit Weight	0.91 G/cm^3
Average Diameter	0.034 mm
Average Length	12 mm
Acid And Alkali Resistance	Very Good
Dispersibility	Excellent

3.0 Method

3.1 Proctor test

The results of this experiment demonstrate that there is a direct correlation between the dry density of the soil and the amount of moisture that the soil contains.

The experimental set-up is comprised of the following elements and components:

- Cylindrical metal mould (internal diameter- 10 cm and internal height-13 cm)
- Detachable base plate
- Collar (5 cm effective height)
- Rammer (2.5 kg).

The following elements combine to form the whole:

- The process of compaction serves to increase the bulk density by removing air from cavities in the material being compacted. The experiment was designed to test the hypothesis that the dry density of soil is dependent, in any compactive effort, on the amount of moisture already present in the soil. This moisture level is referred to as the optimal moisture content, and it is attained when the soil is compacted at a reasonably high moisture content and practically all of the air is pushed out. The maximum dry density (MDD) is reached at this moisture content (OMC). We are able to calculate the OMC and MDD once we have plotted the data from the experiment with the water content serving as the abscissa and the dry density serving as the ordinate. The following equations were used in the course of this investigation:

$$\text{Wet density, } \gamma = \frac{\text{weight of wet soil in mould (g)}}{\text{volume of mould (cc)}} \qquad (1)$$

$$\text{Moisture content \%} = \frac{\text{weight of water (g)}}{\text{weight of dry soil (g)}} \times 100 \qquad (2)$$

$$\text{Dry density, } \gamma_d\ (\text{gm/cm}^3) = \frac{\text{wet density}}{1 + \frac{\text{moisture content}}{100}} \qquad (3)$$

3.2 Unconfined compressive strength (UCS) test

In order to compute the unconsolidated, undrained shear strength of unconfined soil, this test is performed to estimate the unconfined compressive strength of the soil specimen. This, in turn, is used to get the unconfined shear strength. The unconfined compressive strength, abbreviated as qu, is the compressive stress at which a cylindrical sample of unconfined soil fails a basic compression test. The compression device and dial gauges for both load and deformation are included in the experimental setup. The load was measured using the strain dial gauge at a series of various values, beginning with $\varepsilon = 0.000$ and progressing upwards by 0.007 at each stage. After calculating the load for each step, the compressive stress was determined by dividing the load by the corrected cross-sectional area. The calculation of the corrected cross-sectional area was performed by dividing the area by $(1- \varepsilon)$.

qu = load/corrected area (A’) …(4)

qu is compressive stress …(5)

A’= cross-sectional area/ $(1- \varepsilon)$ …(6)

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4.0 Results and Discussions

In the following set of comparison charts, the influence that different quantities of PP fibre had on the outcomes of the proctor test and the UCS test is laid forth.

4.1 Proctor test

Figure 1: Water Content Vs Dry Density (Parent Soil)

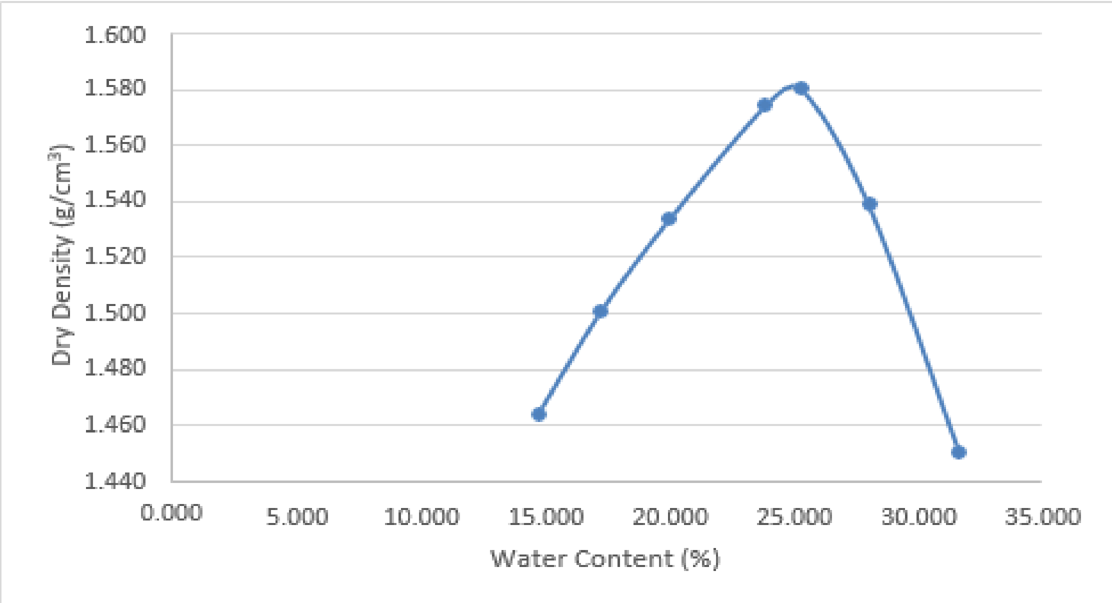
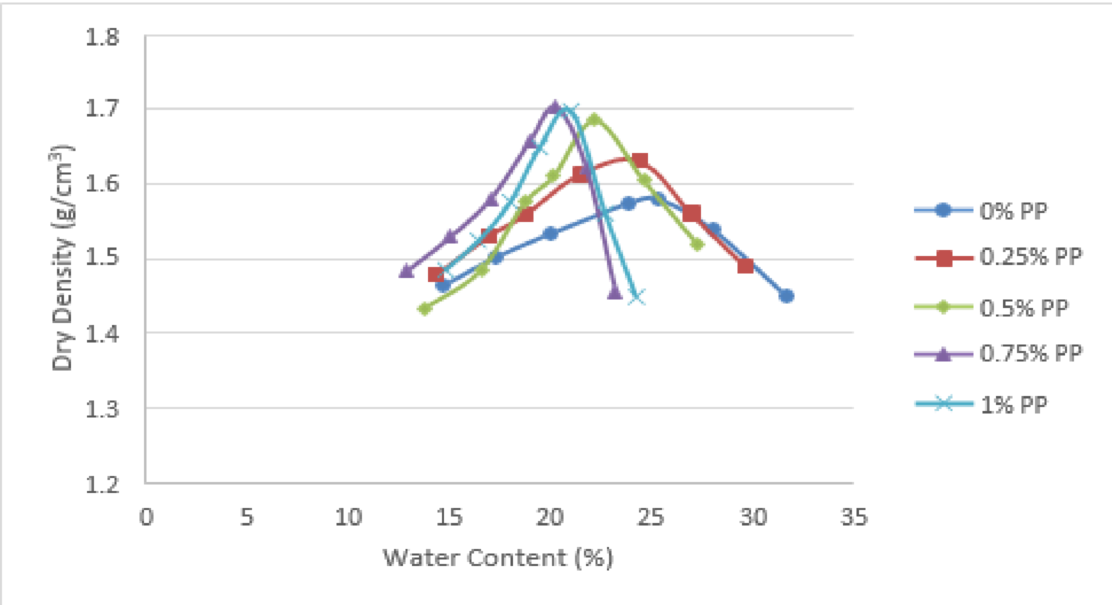
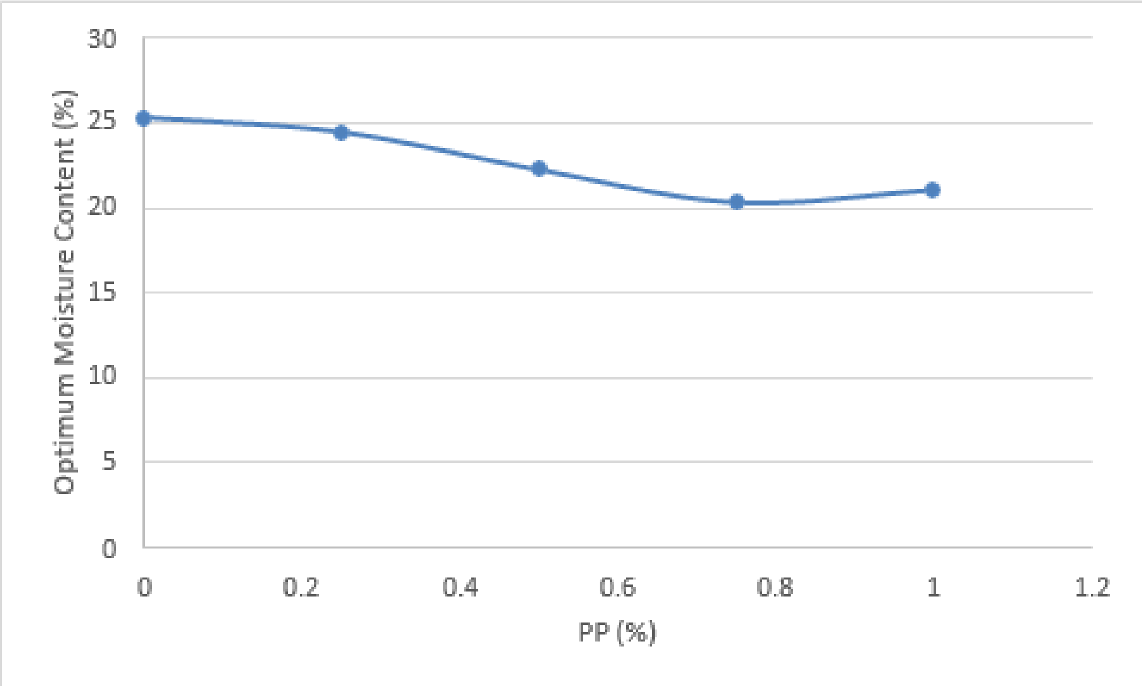


Figure 2: Proctor Test Comparison Curve for Different PP Fiber %



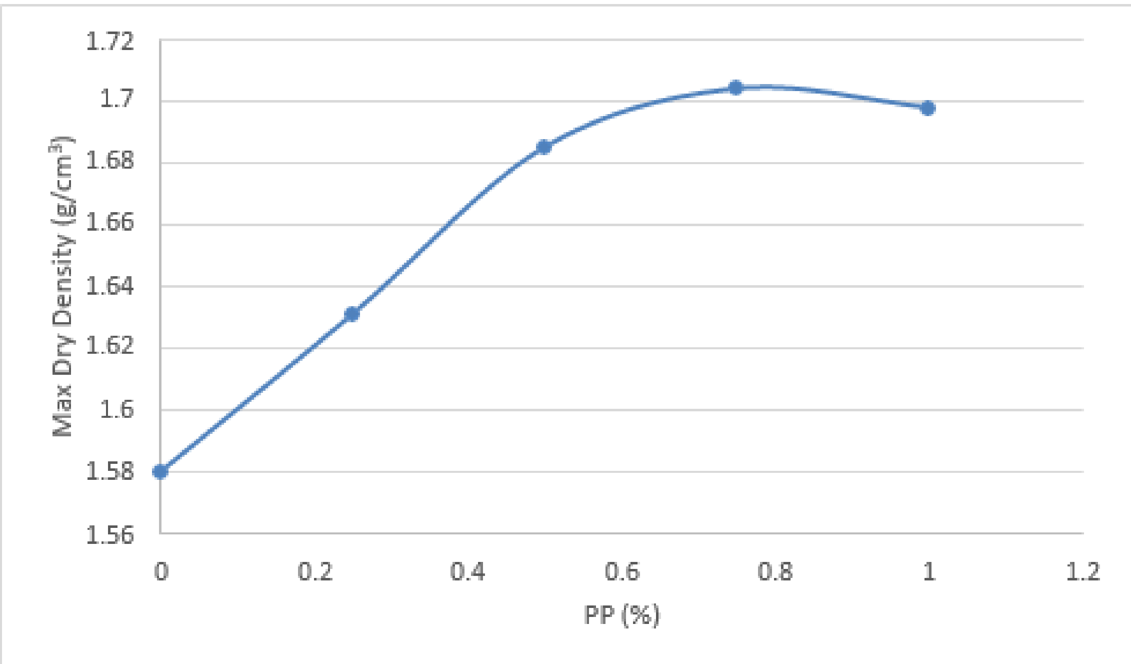
4.2 Effect of PP on optimum moisture content (OMC)

Figure 3: Plot between Optimum Moisture Content (%) and PP (%)



4.3 Effect of PP on maximum dry density (MDD)

Figure 4: Plot between Maximum Dry Density (g/cm^3) and PP (%)



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4.4 Effect of PP on unconfined compressive strength (UCS)

Figure 5: Plot between Axial Compressive Stress (kg/cm2) and Axial Strain for Parent Soil

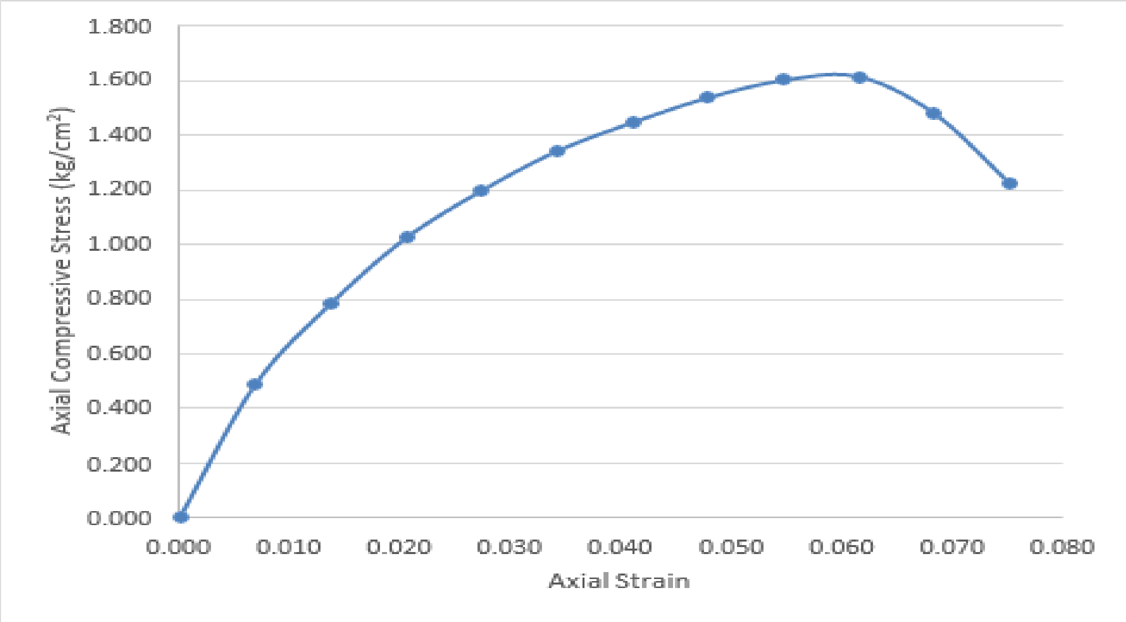


Figure 6: UCS Test Comparison Curve for different PP Fiber %

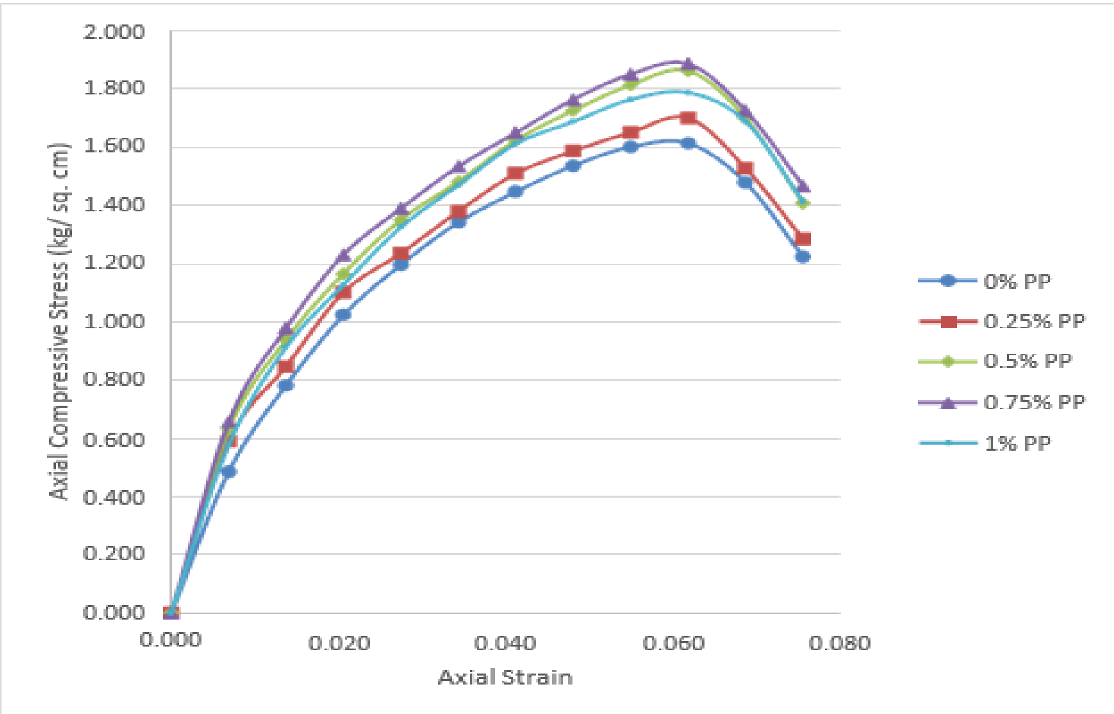
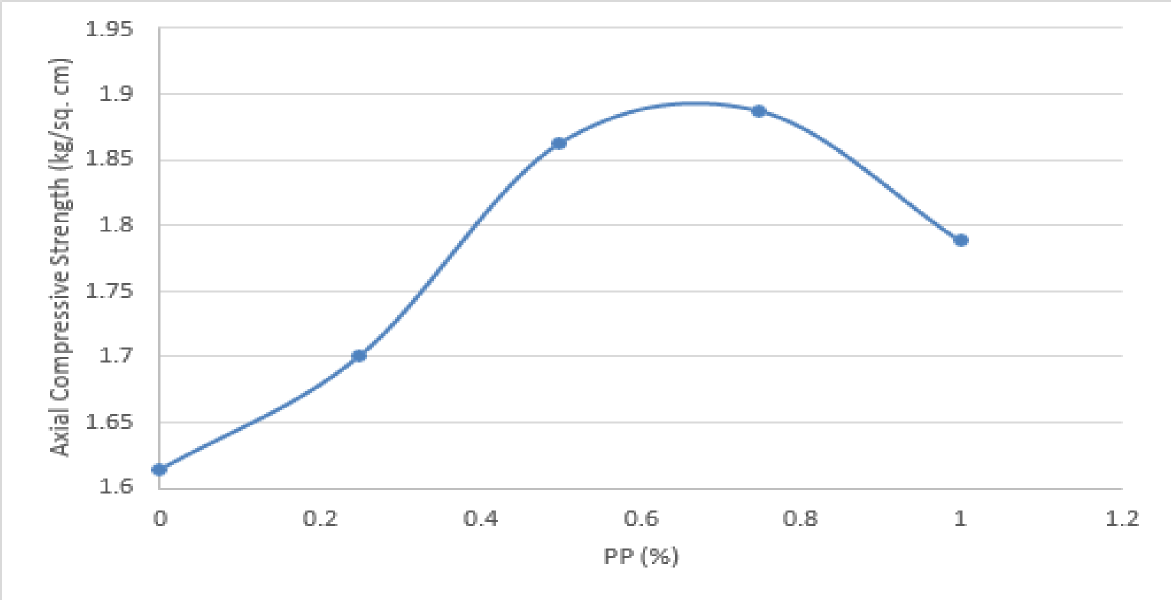


Figure 7: Plot between Axial Compressive Strength (kg/cm2) and PP Fiber %



5.0 Conclusion

On the basis of the current experimental investigation, it is possible to make the following conclusions:

- The findings that were obtained for various proportions of polypropylene are shown in figure 4. The decrease in the optimal moisture content (OMC) is shown in the figure below with various amounts of polypropylene fibre added (0.25 percent, 0.5 percent, 0.75 percent &1 percent). After the OMC has decreased to a level of 0.75 percent, it begins to progressively grow as more polypropylene fibre is included into the mixture. It has been shown that a dose of 0.75 percent polypropylene fibre produces the best results.
- The findings obtained for various proportions of polypropylene, as shown in figure 3, are as follows:

The increase in Maximum dry density (MDD) that can be seen in the figure after varying the amount of polypropylene fibre added in terms of percentages (0.25 percent ,0.5 percent ,0.75 percent &1 percent). After reaching a maximum of 0.75 percent, the MMD begins a slow but steady decline that continues even after more polypropylene fibre is included. It has been shown that a dose of 0.75 percent of polypropylene fibre produces the best results.

- The findings that were obtained for various proportions of polypropylene are shown in figure 4. The increase in compression strength, as illustrated in the picture, with varying proportions of polypropylene fibre addition (0.25 percent, 0.5 percent, 0.75 percent &1 percent). Beyond the OMC reaches 0.75 percent, the compression strength continues to improve, but after that point it begins to steadily decline as more polypropylene fibre is added. Therefore, 0.75 percent of polypropylene fibre was shown to be the optimal dose.
- The use of the fibre reinforcing soil resulted in an increase in the strength of the soil, which led to an increase in the soil's bearing capacity. It is more expensive and energy efficient to raise the bearing capacity of the soil than than opting for a deep foundation or a raft foundation. This is

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true in both cases. Because it generates a considerable improvement in both the compressive and shear strengths of the soil, the use of polypropylene fibre as a stabiliser in soil stabilisation is desirable.

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