Stabilization of Red Soil using Potassium Hydroxide Treated Polypropylene Fiber

Niket Kumar Mishra, M.K. Mishra, J.P. Singh

Abstract: Red soil is not commonly used alike other kind of soils in engineering field. So, a trial is created to stabilize the red soil by adding potassium hydroxide treated polypropylene fibers. This project work aims to search out the effect of addition of 0%, 0.25%, 0.5%, 0.75%, 1%, 1.25% treated polypropylene fibers to stabilize the red soil. Its consistency properties, compaction properties, and strength parameter are tested. In this project the results of addition of treated polypropylene fiber is investigated and is compared therewith of the untreated red soil. The testing program was conducted in two phases. Within the first phase, the physical, and chemical engineering properties of the red soil samples were studied by conducting Specific gravity, Grain size distribution, Liquid limit, Plastic limit, UCS and CBR Tests. Within the second phase of the test program, red soil was mixed with 0%, 0.25%, 0.5%, 0.75%, and 1% of treated polypropylene fiber as percentage of dry weight of red soil. After mixing different percentage of polypropylene fiber and conducting various tests we ought to observed that the value of UCS was increased by 93.12% at 0.75% PP fiber, which makes clear that higher load can be beared after adding it. The value of MDD was also increased by 3.3 %. The soaked CBR value has been increased from 4.24% to 6.37% with 0.75% of polypropylene fiber by which it's cleared that it can be used for pavement in areas where water table is high. Unsoaked CBR value has been increased from 8.32% to 11.06% with 0.75% of polypropylene fiber.Which make clear that we can increases the slope of pavement for stability of slope and also reduce the thickness of pavement in highway and railway which reduces the cost of construction.So, we observed that 0.75 % of treated polypropylene fiber can be used to stabilize the red soil.

Keywords: Soil Stabilization, Polypropylene Fiber, Red Soil, Unsoaked CBR.

I. INTRODUCTION

Soil stabilization is termed for any physical, chemical, mechanical or combined method of fixing a natural soil to satisfy an engineering purpose. Improvements include increasing the load bearing capabilities, durability, and overall performance of in-situ sub soils, sands, and waste materials so onto strengthen road pavements.The method of soil stabilization helps to attain the desired properties in a soil needed for the construction work. Soil stabilization improves the strength of the soil, thus, increasing the soil bearing capacity. It's more economical both in terms of cost and energy to increase the bearing capacity of the soil.

Recent technology has increased the varieties of traditional additives used for soil stabilization purposes (Hetram Sharma, 2016). Such non-traditional stabilizers include-
Polymer based products, Copolymer Based Products, fiber reinforcement etc. A variety of the renewable technologies are enzymes, surfactants, biopolymers, synthetic polymers, co-polymer based products, cross-linking styrene acrylic polymers, tree resins, ionic stabilizers, fiber reinforcement, salt, calcite, binary compound, magnesium chloride and more. A variety of these new stabilizing techniques create hydrophobic surfaces and mass that prevent road failure from water penetration or heavy frosts by inhibiting the ingress of water into the treated layer.
Polypropylene could be a thermoplastic polymer. It's high melting point, high ignition point, low thermal and electrical conductivity and hydrophobic and chemically inert nature which doesn't absorb or react with soil moisture or leachate, and its cost is low. When mixed with soil it acts as reinforcement within the soil and increases the soil property and also increases the ductility of the soil .Due to its hydrophobic and chemically inert nature it doesn't absorb the water and doesn't react with the water and soil particles. These fibers remain same after a few years also. It doesn't leach out and from previous literature review (Ali sinansoganci, 2015), it had been observed that Polypropylene fiber can be a decent stabilizing material. These polypropylene fibers are of 12 mm length. These micro fibers prevent crack formation in soil and provide reinforcement in soil. They are mainly employed in mortar where thickness of plaster is 10 mm or more. They are suitable for waterproofing or repair of structures. Hence this fiber is suitable for the stabilization of soil.

II. MATERIALS USED

Raw red soil were collected from Baliapur road, Dhanbad, Jharkhand and then sent to soil laboratory of Civil Engineering Department, BIT Sindri. The soil were spread on the floor for natural drying and then were broken into smaller size so that it can be used in experiments,
The potassium hydroxide chemical is collected from the laboratory of Chemistry Department, BIT Sindri.
The polypropylene fiber is brought from Siddha Chemicals, Pune, and Maharashtra.

A.Properties of the raw red soil

The red soil sample used in this project has been collected from Baliapur, Dhanbad. It was dug from depth of 1.5m to 2 m below the ground surface by open excavation. After that it was dried and shattered to perform the experiments.

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Table-I: Properties of the natural red soil

S. No.	Parameters	Values
1.	Specific gravity	2.61
2.	OMC	14.28 %
3.	MDD	1.82 g/cc
4.	Liquid limit	27.30 %
5.	Plastic limit	16.93 %
6.	Plasticity index	10.37 %
7.	UCS	5.09 kg/cm^2
8.	Soaked CBR	4.24 %
9.	Unsoaked CBR	8.32 %
10.	Percentage finer(clay + silt)	9.25%

B.Polypropylene Fiber

Below is the specification of polypropylene fiber provided by the supplier (Siddha Chemicals, Pune)

Table-II: Specification of PP fiber

Material	100% virgin polypropylene (PP)
Length	12.0+/- 0.25mm
Diameter	24 micron (approx.)
Aspect ratio	500 (approx.)
Melt point	162 degree centigrade
Specific gravity	0.91
Thermal and electric conductivity	Low
Alkali resistance	100% alkali proof
Acid and salt resistance	High

Fig.1. Polypropylene fiber

Fig.2. 12mm size fiber

III. FORMATION OF SAMPLE

A. Treatment of polypropylene fiber

Due to hydrophobic nature, the polypropylene fiber do not absorb moisture content. It can't be dispersed in water so we would be using KOH solution for total dispersion.We would be treating polypropylene fiber in following steps:-

- Make the solution of 2% KOH.
- Weight the Polypropylene fibers keep it fully dispersed for 24 hours.
- Take out Polypropylene fibers from KOH solution and wash it with distilled water.
- Dry it in oven for 4-6 hours at temperature of 70ºC-80ºC.
- We will again weight the fiber to insure that no weight gain is there and the fiber obtained is dispersed and can be used in red soil.

Fig.3. Dispersion of polypropylene fiber

B. Mixing and Adding

- Firstly various percentages of polypropylene fiber i.e. 0.25%, 0.5%, 0.75%, 1.0% and 1.25% by weight of red soil are used.
- After that treated polypropylene fibers are mixed with red soil properly to get uniform mixture and we will add water as per use.

Fig.4. Mixing of PP fiber with red soil

C. Sample preparation for Testing of Red soil

We will prepare different samples with different amount of polypropylene fiber which is shown in figure below.

Table-III: Sample preparation

S.N.	Percentage of red soil (by weight)	Percentage of PP Fiber (by weight)
1	100%	0%
2	99.75%	0.25%
3	99.50%	0.50%

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4	99.25%	0.75%
5	99.00%	1.00%
6	98.75%	1.25%

IV. EXPERIMENTAL DETAILS

A. Variation of maximum dry density with the variation of polypropylene fibers percentage

By conducting the standard proctor test, it was observed that the maximum dry density of fiber reinforced red soil at optimum moisture content increased with increasing amount of polypropylene fiber, and the maximum dry density-percentage of polypropylene fiber relationship shows that increase in the fiber content up to 0.75 % by dry weight of soil has significant effect on the magnitude of maximum dry density (MDD) and optimum moisture content. The variations of maximum dry density with polypropylene fiber are shown in above figure. The above graph shows the Maximum dry density of soil increases with the increase in polypropylene fiber up to 0.75% of PP fiber and then decreases, but the increment in MDD is not much more due to low density of PP fiber.

This table and graph shows the Variation of maximum dry density with the variation of polypropylene fibers percentage.

Table-IV: Values of OMC & MDD Test result.

S.N.	Soil (%)	PP (%)	MDD (g/cc)	OMC (%)
1	100	0	1.82	14.28
2	99.75	0.25	1.84	13.9
3	99.5	0.5	1.85	13.65
4	**99.25**	**0.75**	**1.88**	**13.42**
5	99	1	1.84	13.79
6	98.75	1.25	1.83	14.12

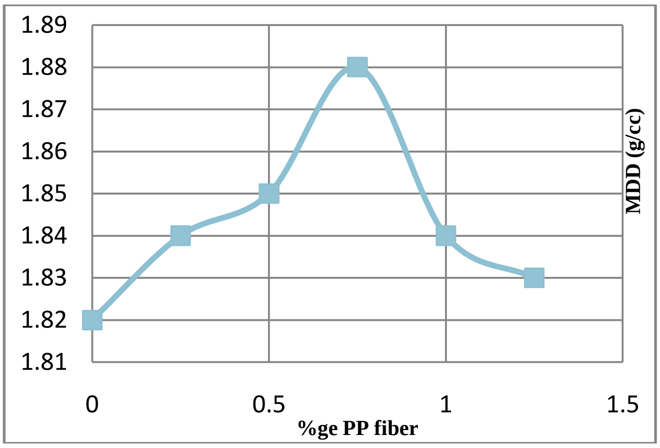

Fig.5. Variation of MDD with % of PPF

B. Variation of UCS of the soil sample mixed with Different percentages of PP fiber

By conducting the unconfined compression test , it was observed that the unconfined compressive strength of natural red soil is 5.09 kg/cm2 and the strength value increases to 9.83 kg/cm2 at polypropylene fiber of 0.75% and then decreases, there is an increase in strength of about 93.12% at 0.75% of fiber content. The variation of unconfined compressive strength with respect to polypropylene fiber is shown above in table and graph.

Table-V: UCS Test results.

S.No.	Soil (%)	PP (%)	UCS (kg/cm^2)
1	100	0	5.09
2	99.75	0.25	5.62
3	99.5	0.5	8.05
4	**99.25**	**0.75**	**9.83**
5	99	1	8.61

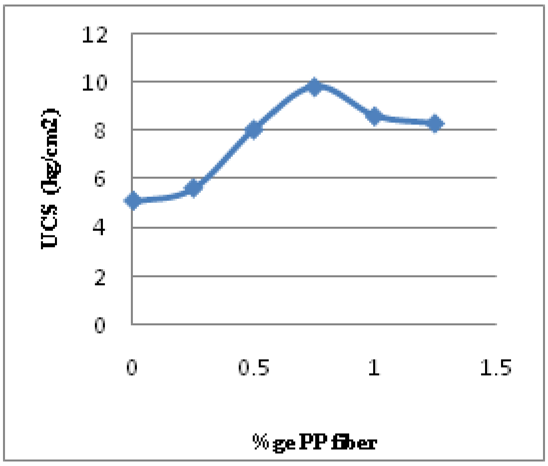

Fig.6. Variation of UCS with % of PPF

C. Variation of UnsoakedCBR of the soil sample mixed withdifferent percentages of PP fiber

The CBR values of the red soil samples mixed with different percentages of PP fiber in Unsoaked condition and its variation with natural red soil have been shown below.

Table-VI: Unsoaked CBR Test results.

S.N.	SOIL (%)	PP (%)	UNSOAKED CBR (%)
1	100	0	8.32
2	99.75	0.25	9.29
3	99.5	0.5	10.42
4	**99.25**	**0.75**	**11.06**
5	99	1	10.45
6	98.75	1.25	10.15

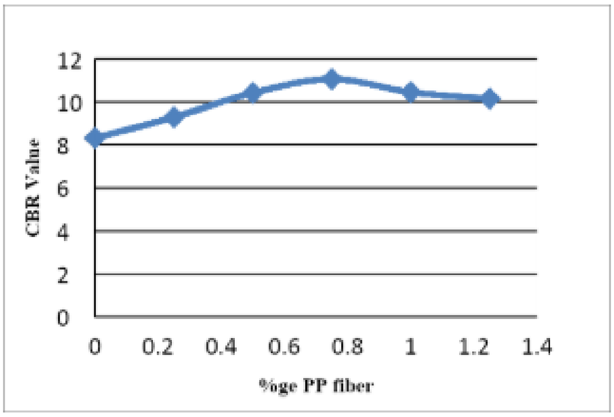

Fig.7. Variation of Unsoaked CBR with % of PPF

D. Variation of Soaked CBR of the soil sample mixed withdifferent percentages of PP fiber

The CBR values of the red soil samples mixed with different percentages ofPP fiber in soaked condition and its variation with natural red soil have been shown below.Similar results were investigated by Dheeraj Kumar, et al (2018) where the effect of sodium hydroxide treated polypropylene fiber on stabilization of soil was studied.

Table-VII: Soaked CBR Test results.

S.N.	SOIL (%)	PP (%)	SOAKED CBR (%)
1	100	0	4.24
2	99.75	0.25	4.94
3	99.5	0.5	5.82
4	**99.25**	**0.75**	**6.37**
5	99	1	6.31
6	98.75	1.25	6.2

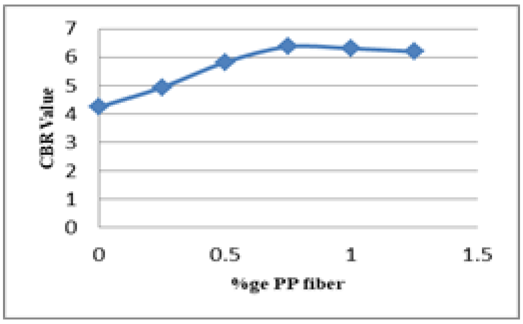

Fig.8. Variation of Unsoaked CBR with % of PPF

E. Comparison between Soaked and Unsoaked CBR according to different percentages of PP fiber.

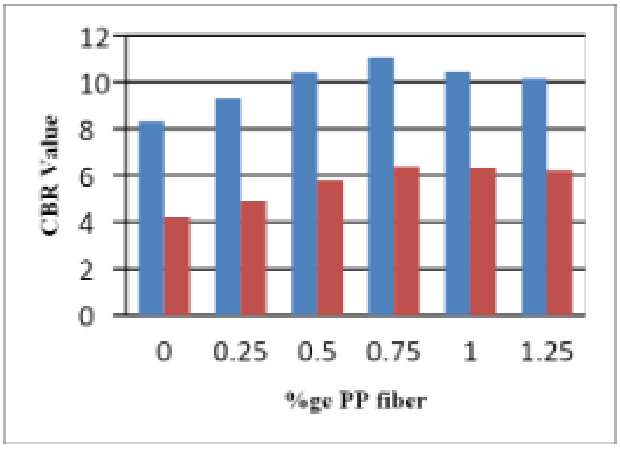

Fig.9. Comparison of Soaked and UnsoakedCBR

Table-VIII: Comparison of Soaked and Unsoaked CBR (red-soaked, blue- Unsoaked)

S.N.	SOIL (%)	PP (%)	SOAKED CBR (%)	UNSOAKED CBR (%)
1	100	0	4.24	8.32
2	99.75	0.25	4.94	9.29
3	99.5	0.5	5.82	10.42
4	**99.25**	**0.75**	**6.37**	**11.06**
5	99	1	6.31	10.45
6	98.75	1.25	6.2	10.15

V. CONCLUSION

By conducting and observing various test results,we observed that the raw red soil with 0.75% of treated PP fiber by weight gives optimum results.

- Unconfined Compressive Strength value has been increased from 5.09 kg/cm2 to 9.83 kg/cm2 with 0.75% of polypropylene fiber. This increment is 93.12%, which makes clear that higher load can be beared after adding it.
- Maximum dry density (MDD) value has been increased from 1.82 g/cm3 to 1.88g/cm3 with 0.75% of treated polypropylene fiber. This increment is 3.3%. It is less because polypropylene fiber was present in low density.
- Optimum moisture content (OMC) value has been decreased from 14.28% to 13.42% with 0.75% of treated polypropylene fiber.
- Soaked CBR value has been increased from 4.24% to 6.37% with 0.75% of polypropylene fiber. By which it is cleared that it can be used for pavement in areas where ground water table is high.
- Unsoaked CBR value has been increased from 8.32% to 11.06% with 0.75% of polypropylene fiber. Which makes clear that we can increases the slope of pavement for stability of slope and also reduce the thickness of pavement in highway and railway which reduces the cost of construction.

Hence, 0.75 % addition of potassium hydroxide treated polypropylene fiber was taken as the optimum percentage to stabilize the red soil.

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