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Experimental Studies on Waste Plastic Fiber Reinforced Soil

Navneeth Kumar[1], Dr. Nayana N Patil[2]

[1]M.Tech. Student, Construction Engineering and Management, Department of Civil Engineering, M.S. Ramaiah University of Applied Sciences, Bengaluru, Karnataka, India.
[2]Assistant Professor, Department of Civil Engineering, M.S. Ramaiah University of Applied Sciences, Bengaluru, Karnataka, India

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Abstract - *To encourage the usage of inferior locally available soil and also to enhance its strength stabilization techniques need to be adopted. Rapid urbanization and industrialization all over the world have resulted in large deposition of waste plastic. Disposal of waste plastic in the environment is a big hazard as it is non-biodegradable. In this paper, an experimental study is carried out to investigate the strength of stabilized soil by adding WPF have been discussed. The main objective of this study is to carry out the laboratory tests on stabilized and unstabilized soil to find out Atterberg limits, shear strength and compression strength. Tests like liquid limit, plastic limit, specific gravity test, UCS, CBR, DST have been conducted. Aspect ratio of WPF in 2mm by 10 mm is randomly placed over the soil sample. From the study it was observed that there is a significant improvement in strength by adding WPF in varying percentages like 0%, 1%, 1.5%, 2%, 2.5%, 3% and 3.5%. From the standard proctor test, for Addition of WPF in the proportions of 1%, 1.5%, 2%, 2.5%, 3%, 3.5% percentages tend to decrease in MDD from 1.705%, 1.692% and 1.597% up to 2% of addition of WPF and there is a slight increase in MDD from 1.67% for 2.5% and there is decrease in MDD from 1.641%, 1.660% for 3% and 3.5% with increase in OMC from 17.3713%, 21.42857% and 26.667% up to 2% and decrease in OMC from 16.67%, 16.67%, 16.12% up to 3.5%. And from CBR test, for Addition of WPF in the proportions of 1%, 1.5%, 2%, 2.5%, 3%, 3.5% percentages it was found that there is increase in CBR value from 3.169%, 3.565%, 3.862%, 3.76%, 6.7% and 6.33%. similarly, from UCC test, for Addition of WPF in the proportions of 1%, 1.5%, 2%, 2.5%, 3%, 3.5%, percentages it was found that there is an increment in shear strength of the soil from 0.018N/mm^2, 0.020N/mm^2, 0.021N/mm^2, 0.139N/mm^2, 0.226N/mm^2 and 0.224N/mm^2. And similarly Based on the results of DST, for Addition of WPF in the proportions of 0%, 1%, 1.5%, 2%, 2.5%, 3%, 3.5% percentages, it was found that there is increment in shear stress of the soil from 0.0085% N/mm^2,0.0089 N/mm^2, 0.0183 N/mm^2, 0.0269 N/mm^2, 0.0301 N/mm^2, 0.034 N/mm^2 and 0.0338 N/mm^2 for 0.5kg of applied load, 0.0087 N/mm^2, 0.0092 N/mm^2, 0.019 N/mm^2, 0.0273 N/mm^2, 0.0313 N/mm^2 ,0.0346 N/mm^2 and 0.0332 N/mm^2 for 1kg of applied load and 0.0089 N/mm^2, 0.0094 N/mm^2, 0.020 N/mm^2, 0.028 N/mm^2, 0.0317 N/mm^2, 0.035 N/mm^2 and 0.0336 N/mm^2 for 1.5kg of applied load. From overall test results we found that there is increase in shear strength, compressive strength for different proportions of the WPF.*

***Key Words*: OMC (Optimum Moisture Content), MDD (Maximum Dry Density) CBR (California bearing ratio), DST (Direct shear test), UCS (unconfined compression test), WPF (Waste plastic fibers).**

1. INTRODUCTION

Plastic when mixed with soil behaves like a fiber reinforced soil. When plastic waste/fibers are distributed throughout a soil mass, they impart strength isotropy and reduce the chance of developing the potential planes of weakness. Plastic wastes/fibers could be introduced either in specific layer or mixed randomly throughout the soil. Random fiber reinforcement- This arrangement has discrete fibers distributed randomly in the soil mass. The mixing is done until the soil and the reinforcement form a more or less homogeneous mixture. Materials used in this type of reinforcements are generally derived from paper, nylon, metals or other materials having varied physical properties. Randomly distributed fibers have some advantages over the systematically distributed fibers. Somehow this way of reinforcement is similar to addition of admixtures such as cement, lime etc Besides being easy to add and mix, this method also offers decreases chance of potential weak planes which occur in the other case and provides ductility to the soil.

Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties. Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils. The main aim is the creation of a soil material or system that will hold under the design use conditions and for the designed life of the engineering project. The properties of soil vary a great deal at different places or in certain cases even at one place; the success of soil stabilization depends on soil testing. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying it on the field.

2. Materials used for study

2.1 Waste Plastic fiber

Figure 1; showing the plastic fiber with an aspect ratio of 2:10 is randomly placed over the soil mass and mixed thoroughly with varying percentages and then stabilized to improve the strength parameters.

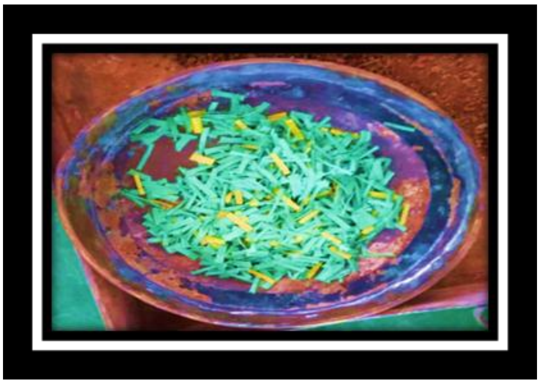

Fig-1: plastic fiber

2.2 Soil sample

The Soil sample shown in Figure 2 is obtained from M S Ramaiah campus. Bigger size lumps were removed and the soil retained on 4.75mm sieve is collected. Then it was oven dried for 24 hours at 105°c to 110°c.

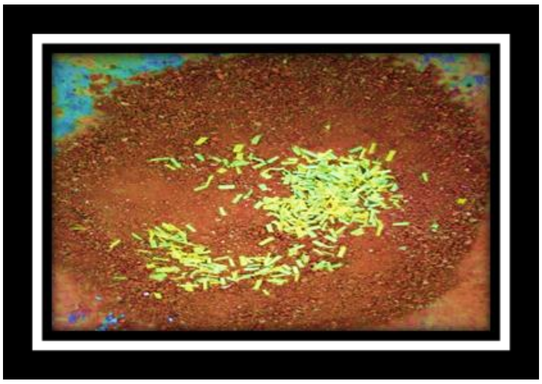

Fig-2: Soil Sample with WPF

3.0 Methodology

All the laboratory tests conducted for unstabilized and stabilized soil. laboratory tests such as Atterberg's limit, standard compaction, CBR, Unconfined compressive strength test and Direct shear test were carried out on soil sample. The present study focuses on evaluating the physical properties, compaction characteristics and strength behaviour. Experimental investigations have been carried out on unstabilized and stabilized soil with the addition of varying percentages of WPF from 0% to 3.5%. The specific gravity of the soil sample was determined according to the Indian Standards, IS: 2720 (Part-3) (1980). The grain size analysis of the soil was determined in accordance with IS: 2720 (Part-4) (1985). For determination of Atterberg's limits IS: 2720 (Part-5) (1985). To determine the compaction characteristics of the soil IS: 2720 (Part-7) (1980) has been used. Unconfined compressive strength (UCS) testing has been carried-out on the soil in accordance with the IS: 4332 (Part-5) (1970). California bearing ratio test was conducted according to IS: 2720 (Part-16). Direct Shear test was conducted according to IS: 2720 (part 13) (1986).

4.0 Results and Discussion

Various laboratory tests have been conducted on Soil sample as per IS codes:

The objective of present study is to investigate the liquid limit, plasticity index, compaction characteristics, UCS, CBR and Shear strength characteristics of soil by the addition of 0%, 1%, 1.5%, 2%, 2.5%, 3% and 3.5% of varying percentages of waste plastic fiber. Addition of WPF tends to increase in OMC and decrease in MDD from 0% to 2%, thereafter there is slight Decrease in OMC from 2.5% to 3.5% WPF with increase in MDD at 2.5% and there is slight Decrease in MDD at 3% and 3.5% WPF as shown in the Table1. CBR value is increased drastically from 3% to 3.5% by addition of WPF as shown in the Table1. Compressive strength of soil increased with addition of WPF from 2.5% to 3.5% as shown in the Table1. Similarly Shear Strength of the soil is increased from 2.5% to 3.5% as shown in the Table 1. The graphical representation of results is shown from figure 3 to figure 7. Table 1 shows the results of experiment conducted on different percentages of stabilizer.

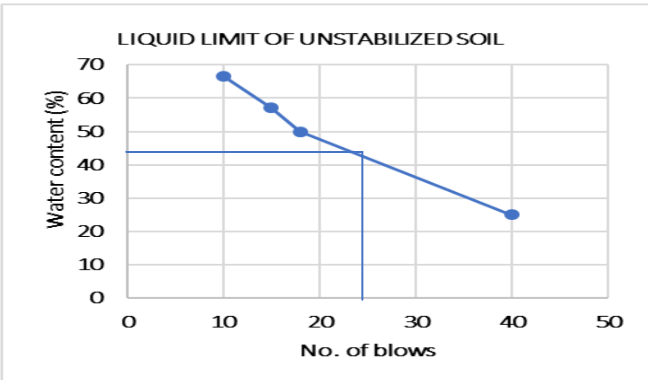

Chart -1: Graphical Representation of LIQUID LIMIT for unstabilized soil

W_L = 41.5 %, W_P = 25 %, PI = 16.5 %

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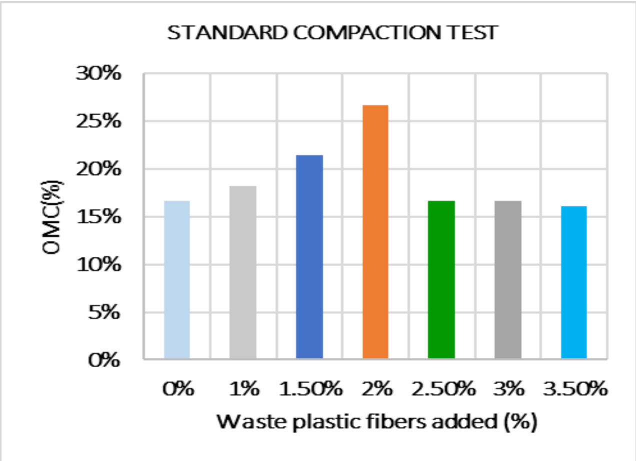

Chart -2: Graphical Representation of OMC for Varying percentages of Soil+ WPF

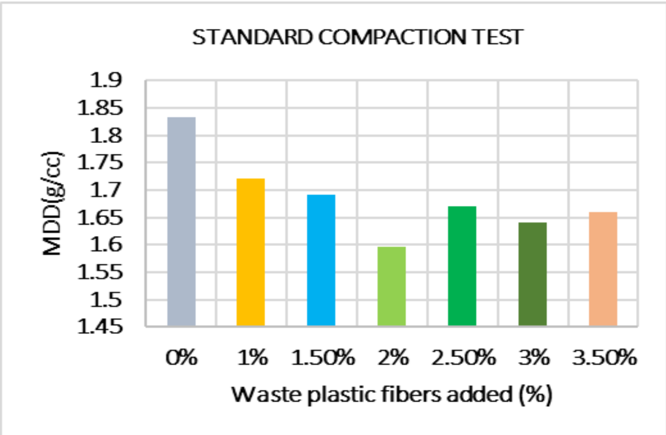

Chart-3: Graphical Representation of MDD for Varying percentages of Soil+WPF

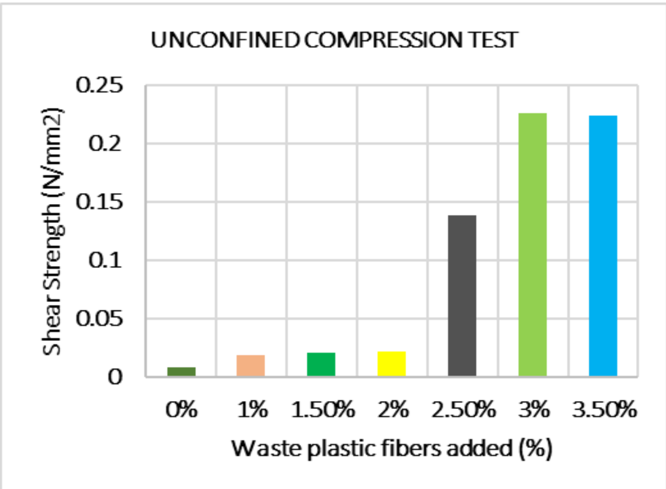

Chart-4: Graphical Representation of UCS for Varying percentages of Soil+WPF

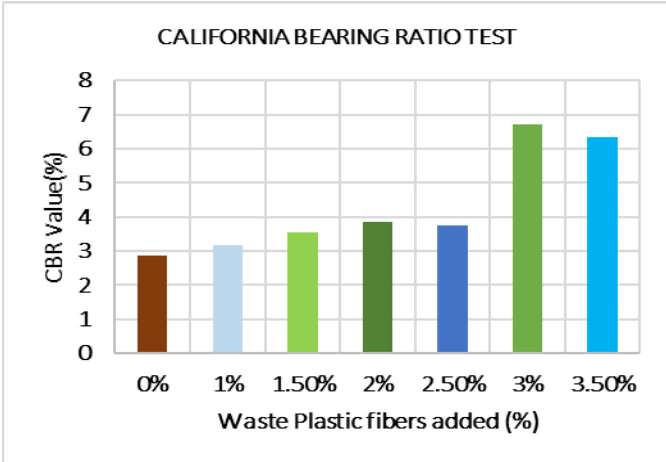

Chart-5: Graphical Representation of CBR for Varying percentages of Soil+WPF

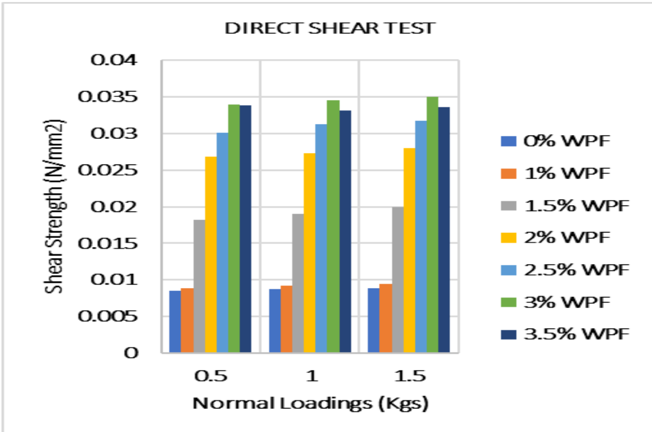

Chart -6: Graphical Representation of DST for Varying percentages of Soil+WPF

Table -1: Results for different percentages of WPF

WPF (%)	OMC (%)	MDD (g/cc)	UCS (N/mm^2)	CBR (%)
0%	16.67	1.834	0.008	2.87
1%	18.18	1.72	0.0185	3.16
1.5%	21.42	1.692	0.0205	3.53
2%	26.66	1.597	0.0215	3.84
2.5%	16.67	1.67	0.139	3.76
3%	16.67	1.64	0.226	6.7
3.5 %	16.12	1.66	0.224	6.33

Table II: Results of DST for different percentages of WPF

WPF (%)	DST (N/mm^2)		
	0.5 Kg	**1 Kg**	**1.5 Kg**
0%	0.0085	0.0087	0.0089
1%	0.0089	0.0092	0.0094
1.5%	0.0183	0.0190	0.0200
2%	0.0269	0.0273	0.0280
2.5%	0.0301	0.0313	0.0317
3%	0.0340	0.0346	0.0350
3.5%	0.0338	0.0332	0.0336

Where,

WPF = Waste plastic fiber

OMC = Optimum moisture content

MDD = Maximum dry density

UCS = Unconfined compression strength

CBR = California bearing ratio

DST = Direct shear test

5.0 CONCLUSIONS

The present experimental studies were carried out to find out the stabilization of soil by using WPF. The conclusion is based on best results obtained for Addition of soil by WPF from 0% to 3.5% respectively. The following conclusions have been drawn based on the laboratory investigations carried

- From Standard Compaction Test we can observe that, there is Increase in OMC from 16.67 % to 26.66% by addition of WPF upto 2% and thereafter there is slight Decrease in OMC from16.67% to 16.12% upto 3.5% WPF

- From Standard Compaction Test we can observe that, there is Decrease in MDD from 1.83 g/cc to 1.59g/cc by addition of WPF upto 2% WPF and there is increase in MDD by 1.67g/cc at 2.5% and there is slight Decrease in MDD at 3% and 3.5% WPF

- Based on the results from UCS Test

  We can observe that, there is increase in compressive stress strength of soil by addition of WPF from 0.008 N/mm^2 to 0.224 N/mm^2.

- Based on the results from CBR Test

  We can observe that, California bearing ratio is increased by 2.87% to 6.33% for varying percentages of addition of WPF.

- Based on the results from DST Test

  We can observe that, there is increase in shear stress with increase in the normal loading with same % of plastic fiber from 0.0085N/mm^2 to 0.0338N/mm^2, 0.0087N/mm^2 to 0.0332N/mm^2 and 0.0089N/mm^2 to 0.0336N/mm^2 for 0.5Kg, 1Kg and 1.5Kg of normal loading.

- Based on the results of all the major tests, we can observe that there is an increase in all the parameters for the selected percentages of Waste Plastic fibers i.e. (1%, 1.5%, 2%, 2.5%, 3%, 3.5%)

- As per results of our current study, from the major tests, we can observe that maximum strength is achieved at 3% WPF and found that the best possible % of Waste plastic fiber.

6.0 REFERENCES

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BIOGRAPHY

Navneeth Kumar received a Bachelor degree in civil engineering from Sri Venkateshwara College of Engineering (SVCE), Bengaluru in 2017 and a Master Degree in Construction engineering and management from M.S. Ramaiah University of Applied Sciences (MSRUAS), Bengaluru in 2019. He is currently interested in research in the field of construction.