Strength Improvement of Clayey Soil With Polypropylene Fiber and Wheat Husk Ash

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Abstract

Soil is the origin of everything. As we know everything is dependent on nature, and as a civil engineer we know that soil plays a vital role in construction. In this research paper we performed various test on soil to know its properties or strength by using agricultural waste material such as wheat husk ash (WHA) as a stabilized material in soil with varying percentages 10%, 20%, 30%,40%. Soil samples for California bearing ratio (CBR) tests and UCS are prepared at its maximum 8dry density (MDD) corresponding to its optimum moisture content (OMC) in the CBR mould and UCS sampler without and with Polypropylene Fiber. The percentage of Polypropylene Fiber by dry weight of soil is taken as 0.5%, 1%, 1.5% and 2% and corresponding to each Polypropylene Fiber content soaked CBR tests and UCS tests are conducted in the laboratory. Tests result indicates that soaked CBR and UCS value of soil increases with the increase in Polypropylene Fiber content. Adding of Polypropylene Fiber and Wheat Husk Ash results in less thickness of pavement due to increase in CBR of mix This is because of composite effect of Polypropylene Fiber and Wheat Husk Ash changes the brittle behaviour of the soil to ductile behaviour.

Keywords:- *Clayey soil, wheat husk ash, polypropylene fiber.*

I. INTRODUCTION

Soil is the uppermost unconsolidated material of the earth present naturally in the universe. It is formed by the decomposition of rocks under the influence of naturally occurring conditions such as wind, rain, snow, heat, etc. It is abundantly available and is the cheapest construction material. It is a complex material because of its highly variable composition and characteristics. The characteristics of soil change according to topography and its location. For safer construction the properties of soil should match with the design requirements of an engineering structure. Geotechnical engineer plays an important role in this work for checking whether the requirements of the structure are fulfilled by the soil or not. Construction of engineering structures on poor soil involves a great risk. These soils show settlements, low shear strength and high compressibility.

Very often the available soil is not suitable for construction purposes. Strength, permeability and stability on slopes are the main aspects of soil that we have to deal with. For studying the engineering behaviour of soil, we have to deal with the stability of underground structures, retaining structures, foundations, slopes, earth dams and pavement construction.

The method of alteration or improvement of the engineering properties of soil to stabilize it is known as soil stabilization. The main effect of stabilization is decrease the compressibility and permeability of soil and to improve its load bearing capacity. Now many new methods have been founded to be used to improve the engineering properties of the unstable soil to increase its stability for designing the structure. Improvement of soil mainly deals with three methods, i.e., removing the unwanted materials, controlling the groundwater conditions and stabilizing the soil.

II. Literature review

Himanshu Gupta et al. (2017)
They used Wheat Husk Ash and Polypropylene material to enhance the properties of natural soil used for subgrade material in pavement. The soil was stabilized different percentages of WH and after getting optimum percentage of WH, PP with percentage of 0.25%, 0.50%, 0.75%, 1.00%, is added along with WH individually, for the construction of sub grade soil and test like Liquid Limit, Plastic Limit, Plasticity Index, Specific Gravity, Optimum Moisture Content, Maximum Dry Density, Swelling Pressure and CBR is performed.

Savitha A.L. et al. (2013)
conducted compaction tests and UCS tests on Black Cotton soil using coarse and fine fly ash. They varied the percentage of fly ash from 5% to 25% with increase of 5% at a time. Curing was done for 1,7,14,28 days. They reported that the strength obtained by fine fly ash was 25% more than that of coarse fly ash. On increasing water content upto 30%, the dry density decreases and if water content is

increased further the dry density decreases gradually. The MDD was 1.35 g/cc for 5% fly ash mixed with 95% soil and lowest density was 0.6g/cc for 30% fly ash mixed with 70% soil.

Mr. Santosh et al. (2012)

Reported that Addition of different % of Wheat Husk Ash (WHA) the water content decrease up to a limit afterwards again it increases. This is more effective for addition of 9% (optimum) WHA. Addition of different % of WHA the dry density increases up to a limit afterwards again it decreases. This is more effective for addition of 9% (optimum) WHA. The stress against different days for varying % WHA, for varying % of WHA, as number of day's increases stress also increases. This is more effective for 7days.

S. Soganc (2010)

The inclusion of fiber within unreinforced and reinforced soil caused an increase in the unconfined compressive strength of expansive soil. Increasing fiber content had increased the peak axial stress and decrease the loss of post-peak strength. For example, unconfined compression strength increased from 202 MPa to 285 MPa for samples reinforced with 1% fiber. The fiber reinforced soil exhibits more ductile behavior than unreinforced soil. Swell percent was reduced as the fiber increased. One dimensional swell decreased considerably with 1% fiber addition. For example it decreased from 11.60% for unreinforced samples to about 5.3% for reinforced samples with 1% fiber.

Agrawal M.L. et al. (2013)

performed compaction tests and CBR test on black cotton soil. They varied the percentage of flyash from 10% to 50% with increase of 10% at a time.They investigated that the MDD increases with increment in fly ash up to 20% , and with more addition it decreases. The increase in CBR value and dry density is maximum for 30% fly ash mixture with black cotton soil. On increasing percentage of fly ash, there is decrease in thethe liquid limit of black cotton soil, resulting in reduced swelling of soil.

Yanbin Li et al. (2014)

performed compaction test and triaxial shear test on silty clay. They used 0.5%, 1%, 1.5% sisal fiber with lengths 5mm, 10mm and 15 mm. They reported that the stress increased with increase in strain when 1.0% fiber content is taken and they observed no decrease in stress when the strain exceeded 1.0%.They reported that silty clay reinforced with sisal fiber has 20% more strength than non-reinforced clay when 1.0% fiber content of length 10 mm is considered.

Kumar R. et al. (2014)

studied the effect of sisal fibers on the UCS value of bentonite. He reported that there can be an increase in the UCS value of bentonite by adding lime, phosphogypsum and sisal fibers. The highest UCS value was obtained at 8% lime, 8% phosphogypsum and 1% sisal fibers. UCS value increased with increment in fiber from 0.5 to 2% fiber.

Abadi et al. (2014)

conducted compaction test and California bearing ratio test on clay. He varied the percentage of flyash from 5% to 25% with increase of 5% at a time. He reported that the MDD of clay increased with increment in ash till 15%, then decreased to 1.53 at 20% ash. The OMC decreased until 15 %,then after that it started to increase. CBR value reduces slightly when soil ash mixture contains more than 15% ash.

Swarup J. et al.(2015)

performed compaction tests and CBR tests on the black cotton soil. They used sisal fiber (0.25%, 0.5%, 0.75%, 1%, 2%, 3%), NaOH (3%, 6%, 9%, 12%,15%) and flyash 20% by weight of dry soil. They concluded that optimum value of NaOH is 9%, 12N. Normal soil matrix gives the maximum CBR values at nearly 11% of fiber content but due to this stabilization technique,the maximum amount of CBR value can be attained at less amount of fiber content i.e. at 0.2%.

III. Materials and Methods

A. SOIL

Source of soil

The soil used in this study was obtained from jammu. As per IS classification of soil, the soil used is clayey. The soil properties are given in the table as under:

Table no. 3.1 Properties of soil used in the study

S. No.	Properties of soil	Value
1	Specific gravity	2.68
2	Liquid Limit (%)	29
3	Plastic Limit (%)	24
4	Plastic Index (%)	5
5	Maximum Dry Density (kN/m^3)	17.2
6	Optimum Moisture Content (%)	14
7	CBR (soaked)	2.67
8	Unconfined compressive strength (kN/m^3)	178.6

B. WHEAT HUSK ASH

Wheat is the most common and important human food grain and ranks second in total production as a cereal crop. Wheat grain is a staple food used to make flour for leavened, flat and steamed breads etc., Wheat Husk Ash is waste of crop of wheat, which is escaped out while getting grain from crop. Wheat husk ash is a agricultural waste which obtained from burning wheat straw. When crops of wheat is cut then husk is remain in the ground itself, this husk is a complete waste. But now a days by burning these husk its ash can replace by cement. Much literature is not available on wheat straw ash but it completely shows that it posess pozzolanic properties.

Chemical composition of Wheat Husk Ash

S.No	Compound	Wheat Husk Ash
1.	Silica(SiO_2)	43.22
2.	Alumina (Al_2O_3)	25.9
3.	Calcium oxide (CaO)	5.46
4.	Iron oxide (Fe_2O_3)	0.84
5.	Magnesium oxide (MgO)	0.99
6.	Sulphur (S)	0.5

C. POLYPROPYLENE FIBER

Polypropylene (PP) also known as polypropylene, is a thermoplastic polymer used in a wide variety of applications including packing, it is widely use in ready mix concreate and it is easily available in india and other country. According to global market report production of polypropylene since 2013, is 55 million tonnes. In synthetic fiber polypropylene is the world's second widely product after polyethylene. Chemically, polypropylene is denoted is (C_3H_6).

perties of polypropylene Fiber

S. No	Property	Value
1	Lusture	Bright to light
2	Density	0.91gm/c.c
3	Moisture regain (%)	0%
4	Tenacity	3.5-8.0
5	Heat protection	moderate
4	Melting point	170
5	Modulus of elasticity (GPa)	15

EXPERIMENTAL PROGRAMME

The experimental programme for this study includes the processing of materials and their mix proportion to be used for finding various engineering properties of soil- WHA- PP fiber mix. The procedure for conducting tests i.e. standard proctor test, California bearing ratio test, unconfined bearing ratio is discussed in this chapter. All the tests were conducted according to IS code 2720.

Processing of materials

The soil was collected from the site and lumps were broken with wooden hammer. It was air dried and sieved through 2.36 mm IS sieve. Then it was mixed properly and stored in polythene bags. Sufficient quantity of soil was taken from these bags and dried in oven for conducting each test. In the same manner WHA was collected and oven dried for 24 hours. The desired quantity of WHA was taken and mixed uniformly with the soil. The desired amount of pp fiber was then added to the soil- WHA mix. Due care was taken so that a uniform soil- WHA- PP fiber mixture can be obtained.

Mix proportions of Soil(S), (WHA) and (PP)

S.NO	DESIGNATION (S:WHA:PP)
1	100:0:0
2	90:10:0
3	80:20:0
4	70:30:0
5	60:40:0
6	69.5:30:0.5
7	69.0:30:1.0
8	68.5:30:1.5
9	68.0:30:2.0

Laboratory tests

The following tests were performed for the present study:

1. Pycnometer test
2. Liquid Limit test
3. Plastic Limit test
4. Standard Proctor test
5. California bearing ratio test
6. Unconfined compressive strength test

IV. RESULTS AND DISCUSSION

A. Liquid Limits, Plastic Limits and Plasticity Index

Atterberg's Limits Result;

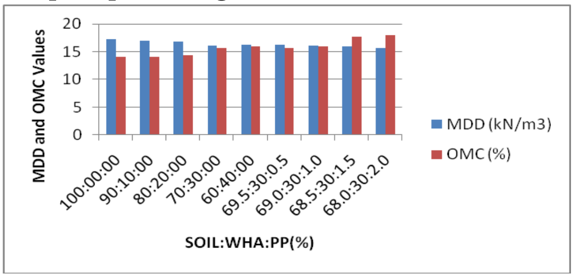
Designation S:WHA:PP(%)	**Liquid Limit**	**Plastic Limit**	**Plasticity Index**
100:0:0	44.3	24.4	21.9
990:10;0	43.8	25.2	25.28
80:20:0	43.5	26.5	21.5
70:30:0	43.1	26.8	19.2
60:40:0	44.3	27	18
69.5:30:0.5	43.2	27.7	15.3
69.0:30:1.0	43.8	27	16.8
68.5:30:1.5	42.8	25.2	17.6
68.0:30:2.0	41.5	26.1	18.7

B. Standard Proctor Test

MDD and OMC Values of various mix proportion

S:WHA:PP (%)	**MDD (kN/m^3)**	**OMC (%)**
100:0:0	17.2	14
90:10:0	17	14
80:20:0	16.8	14.3
70:30:0	16.1	15.6
60:40:0	16.2	16
69.5:30:0.5	16.3	15.6
69.0:30:1.0	16.1	16
68.5:30:1.5	15.9	17.7
68.0:30:2.0	15.7	18

Graph representing MDD and OMC values

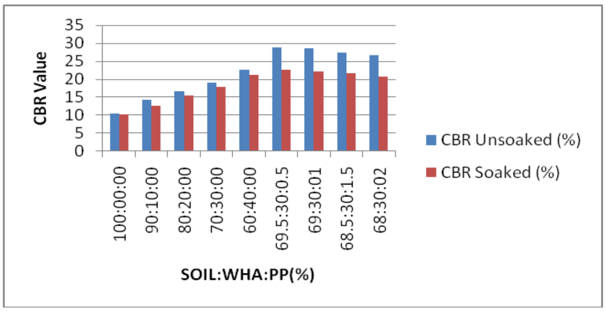


C. California Bearing Ratio Test

CBR values for Soaked and Unsoaked specimen

Mix Type	**CBR Unsoaked (%)**	**CBR Soaked (%)**
100:0:0	10.55	10.22
90:10:0	14.32	12.65
80:20:0	16.78	15.48
70:30:0	18.98	17.85
60:40:0	22.59	21.11
69.5:30:0.5	28.76	22.57
69.0:30:1.0	28.65	22.15
68.5:30:1.5	27.50	21.70
68.0:30:2.0	26.56	20.75

Graphs representing the curves that are obtained from California bearing ratio test for SOIL – WHA-PP fiber mixture

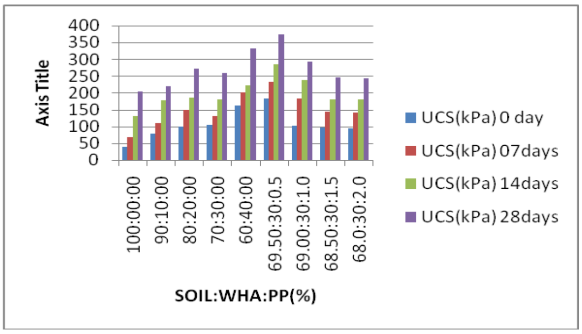


D. Unconfined Compression Strength Test

UCS values for 0 day, 7 days, 14 days and 28 days curing

S:WHA:PP	UCS (kPa)	UCS (kPa)	UCS (kPa)	UCS(kPa)
	0 day	7 day	14day	28 day
100:0:0	38	67	131	203
90:10:0	78	109	178	220
80:20:0	99	148	185	271
70:30:0	104	130	181	259
60:40:0	161	201	222	333
69.5:30:0.5	183	232	286	375
69.0:30:1.0	103	182	239	292
68.5:30:1.5	97	145	180	245
68.0:30:2.0	95	140	180	244

UCS Graph SOIL and WHA and PP



E. Discussions

The optimum mix is determined from the consistency's limit tests. The OMC increases from 14% to 18% and the MDD decreases from 17.2 to 15.7 kN/m^3 from virgin soil to stabilized clay soil. The increase in OMC (from 11% to 18%) is observed at 69.50: 30: 0.5 (Clay: WHA: PPF).

The unconfined compressive strength show that with an increase in curing days there is vast increase in the strength of the samples. The increase in the strength after curing period is varying from 80 kN/m^2 to 690 kN/mm^2. The results also shows that with an increase in the curing period the strain value also goes on increasing but at greater strength, which shows that sample at 28 days resist much amount of load and save our structure from sudden collapse.

The increment in the CBR value is shown in the optimum mix (69.50: 30: 0.5) sample under dry condition is from 10.55% to 28.76%.

V. Conclusions

The conclusions drawn from the experimental investigation are as under:

- When percentage WHA increases in soil there is increase in O.M.C. and decrease in M.D.D.
- With the increase in quantity of PP fiber the value of O.M.C. increases and M.D.D. decreases.
- The optimum value of WHA ash to be used for further work was 30%.
- The best ratio obtained was 69.50% soil: 30% WHA: 0.50% PP fiber.
- Soaked CBR value increases from 10.22% for virgin soil to 22.57% for the best ratio of the mix.
- Unconfined compressive strength of soil-WHA mixtures increase with increase in PP fiber up to 0.50 % by weight.

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