Effect of cement kiln dust and polypropylene fibre on geotechnical properties of clayey soil

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Abstract

Now a days there is immense problem to harmless disposal of industrial wastes. Lot of waste resources are non-biodegradable so they make a environmental contaminated in the locality. Some studies show that in earlier period, manufacturing wastes can be used successfully in road construction. In the process of road making, the use of unwanted materials is based on some industrial, monetary and ecological criteria. Like India is a rising country and has a vast network of manufactories that are positioned in different parts of the country and may more are to establish in next few years. Industrial wastes are formed in huge amount from these industries in thousand tons. The disposal and pollution problems may be controlled by suitably utilizing the waste materials in construction sites. It is very crucial to test the materials properly and to build up a methodology and specifications, to increase the utilization of the industrial wastes for their successful use in road construction.

This paper describes the use of cement kiln dust and polypropylene fibre for soil stabilization. Standard proctor test, California bearing ratio test ,

UCS tests were carried out. The fraction of polypropylene fibre used in this paper is 1.00%,1.50%, and 2.00% along with fixed value of CKD 8%. The different percentage were determined which showed considerable enhancement in the strength of treated soil. The maximum value of C.B.R. is at 08% CKD and polypropylene fibre 2% . additional increase in ratio of polypropylene fibre the C.B.R. value decreases. The UCS value increases considerably with inclusion of CKD and polypropylene fibre Experiment results show polypropylene fibre and cement kiln dust enhances the strength properties of soil along with use of economical materials and also solves the environment problem.

Keywords

Clayey Soil, CKD, PP Fibre, Soil Stabilization.

INTRODUCTION

Soil is considered as a complex material. It has chemical and physical characteristics which are important to deal with the loadings and other external forces. From all the other civil engineering fields soil engineering and soil mechanics is most complex field when the factor of safety is considered in the design of sub-structures e.g. foundations , piles and other soil based constructions like sub-grade for pavements, embankments etc, requires a significantly a higher value of safety in comparison of other construction materials . That's why the uncertainty in soil analysis and foundations designs is higher.

Therefore the engineering properties of the soil are analysed before any major construction work, so as to ensure its stability against the load of the desired structures. The soil normally consists of rock particles , the air and the water are located in the empty spaces (called voids). It is essential to determine the geological characteristics that are influenced by the size of the particles, distribution of the grain size, and the amount of that minerals. The geotechnical properties of the soil are generally are considered for carrying out the analysis of the site conditions and design of structures are the bulk unit weight, saturated unit weight, dry unit weight, permeability and porosity. Several laboratory tests are also conducted to check the permeability, relative density, soil compaction characteristics and water content.

Sometimes the existing soil at a particular site may not be suitable for construction of structures due to its low bearing capacity, drainage problem and other problems like high compressibility etc. Clayey soil if found which is ineffective for the construction due to its low bearing capacity against the load due to its swell-shrink characteristics, there is the requirement to improve its characteristics by changing the properties of such soils by using some wastes such as CKD, rice husk ash etc having pozzolanic and ashitious properties, resulting in reduction of cost of improvement.

LITERATURE REVIEW

Nadgouda K.A. and HegdeRA (2010) had concluded in their study that the optimum lime content varies within 3.5% to 4.5% for the stabilization of clayey soil. The study shows that

the optimum moisture content and the potential for swelling upon contact with water is reduced on treatment with lime.

Heeralal (2011) conducted An experimental program to investigate the effects of discrete short polypropylene fibre (PP-fibre) on the strength and mechanical behavior of soil and soil+ CKD mix. In the present investigation the soil samples were prepared at three different percentages of PP-fibre content (i.e. 0.25%,0.5%,1.0% by weight of the soil) and three different percentages of cement kiln dust content (i.e. 3%,5%,8% by weight of the soil) and unconfined compressive strength, direct shear test and C.B.R tests were carried out. U.C.C tests were carried out after a curing period of 28 days. The test results indicated that the inclusion of fibre reinforcement within soil and soil-CKD mix caused an increase in the unconfined compressive strength (UCS), shear strength, axial strain at failure, decreased the stiffness, and changed the elemented soil's brittle behavior to a more ductile one and C.B.R value increased even for unsoaked condition

Venkatasubramanian and Dhinakaran (2011) performed a series of tests on three different soils having different engineering properties. The tests were performed at different dosages of terrazyme. The values of liquid limit and plasticity index for these three types of soils were reported as 28 , 46 and 30% and 6 , 6 and 5% respectively. The increase in CBR value after four weeks was reported as 157 , 673 % and 152 to 200% in UCS.

Singh (2011) performed compaction test and UCS test on clayey-silt. He showed the effects of using low calcium fly ash and ordinary portland fly ash in improving the strength of a clayey silt soil. He determined that with increment of fly ash in soil, MDD decreases and OMC increases. When only fly ash is added, the soil mixes are to be used for constructing road embankments and sub grade layer of pavements. When 1% fly ash is added to the soil-fly ash mixes, these are be used even for sub-base of low-volume roads.

Manjunath K.R. et al. (2013) studied the effect of propylene fibre on compaction and strength characteristics of black cotton soil treated with lime. They reported that for a particular fibre percentage, the MDD of stabilized soil increases and OMC decreases. The maximum dry density and OMC of propylene fibre reinforced soil increased with 3% lime. 3% of lime content and 0.75% propylene fibre were considered as optimum percentage for black cotton soil to increase the California bearing ratio value.

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.

Agrawal M.L. et al. (2013) performed compaction tests and CBR test on black cotton soil. They varied the percentage of fly ash 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 the the liquid limit of black cotton soil, resulting in reduced swelling of soil.

Peng et al (2011) examined three types of soild and conducted unconfined compression tests on them. The three soils are fined grained soil, silty loam and the coarse grained soil. These three types of soils are treated with quicklime and permazyme. The sample were placed for the curing period of 60 days in two different conditions: (1) sealed container and (2) air dried. Permazyme found more effective in air dried conditions than quicklime. But on the other hand in sealed conditions, the quicklime found to be more effective than permazyme as water was not evaporated and hydration was promoted.

MATERIALS AND METHODS

SOIL

Source of soil

The soil used in this study was obtained from sri sai institute Bungal,Pathankot. As per IS classification of soil, the soil used is low compressibility clayey soil. The soil properties are given in the table as under:

Properties of soil used in the study

S. No.	Properties of soil	Value
1	Specific gravity	2.68
2	Liquid Limit (%)	30
3	Plastic Limit (%)	24
4	Plastic Index (%)	6
5	Classification of soil(According to ISC)	ML (clay of Low Compressibility)
6	Maximum Dry Density (kN/m^3)	17.2
7	Optimum Moisture Content (%)	14
8	CBR (soaked)	2.66
9	Unconfined compressive strength (kN/m^3)	82.52

CKD

Source of ckd

CKD used in this research work was collected from trumboo cement industries, Srinagar.The ckd was dried in oven and then it was sieved for the removal of foreign particles. Properties and composition of ckd as obtained from the cement plant is shown in table no. 3.2 and 3.3

Engineering Properties of ckd (Source: Trumboo cement industries)
Table no. 3.2

1	Colour	Grey
2	Specific Gravity	2.8
3	OMC	26%
4	MDD (kn/m3)	13.65

Chemical Composition of CKD

S. No	Name of constituent	Percentage
1	Silica (SiO_2)	17.84
2	Alumina (Al_2O_3)	4.57
3	Iron Oxide (Fe_2O_3)	2.75
4	Calcium Oxide (CaO)	49.36
5	Magnesium oxide (MgO)	2.56
6	Potassium oxide (K_2O)	3.99
7	Sodium oxide (Na2O)	0.33
8	Free lime	14.4

POLYPROPYLENE FIBRE

Source of polypropylene fibre
The pp fibre used in this study was obtained from Jindaram Exports, Sirsa. PP is a natural fibre having greater tensile strength and can be used as an effective reinforcing material in soil stabilization. The properties and composition of pp fibre are discussed in table.

Properties of PP Fibre
(Source: Jindaram Exports, Sirsa)

S. No	Property	Value
1	Colour	White
2	Specific Gravity (Kg/m^3)	910
3	Water Absorption (%)	110
4	Length of fibre (mm)	12
5	Diameter of pp fibre (mm)	0.034
4	Tensile Strength(MPa)	350
5	Modulus of elasticity (GPa)	3500

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 - ckd - pp fibre mix. The procedure for conducting tests i.e. standard proctor test, California bearing ratio test, unconfined compression tests are i discussed in this chapter. All the tests were conducted according to IS code.

Processing of materials

Sufficient quantity of soil was taken from site and dried in an oven for conducting each test. In the same manner ckd was collected and oven dried for 24 hours. The desired quantity of ckd was taken and mixed uniformly with the soil. The desired amount of pp fibre was then added to the soil- ckd mix. Due care was taken so that a uniform soil- ckd- pp fibre mixture can be obtained.

Laboratory tests

The following tests were performed for the present study:

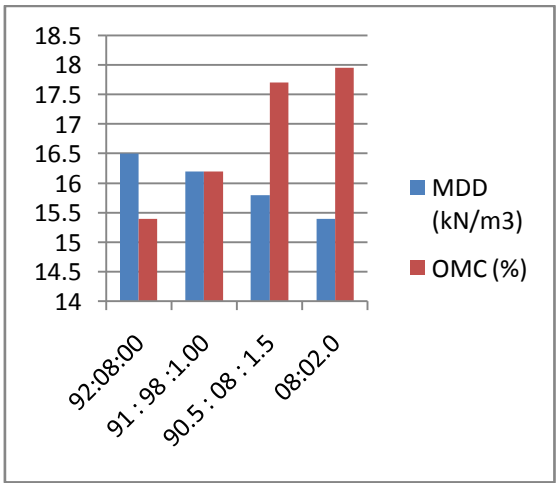
1. Pycnometer test
2. Liquid Limit test
3. Plastic Limit test
4. Standard Proctor test
5. California bearing ratio test
6. Unconfined compressive strength test

Mix proportions of Soil ckd and pp Fibre

S.NO	DESIGNATION (S:CKD:PP)
1	99:1:0
2	97:03:0
3	95:05:0
4	92:08:0
5	91:08:1.00
6	90.5:08:1.50
7	90:08:2.00

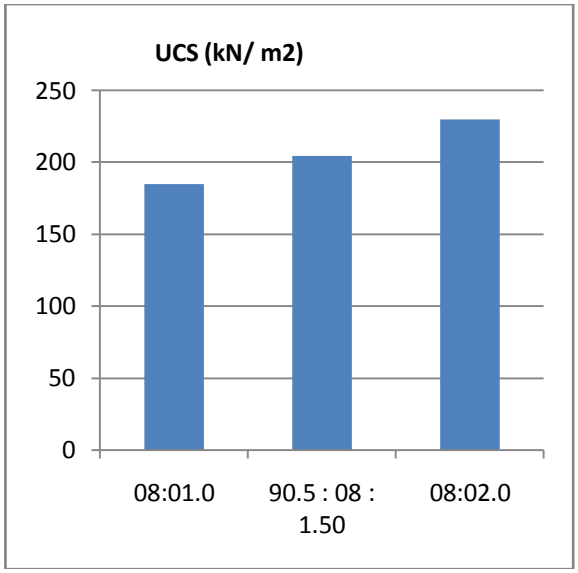
STANDARD PROCTOR TEST

Proportion Soil : ckd : pp fibre	MDD (kN/m^3)	OMC (%)
92:08:00	16.5	15.4
91 : 98 :1.00	16.2	16.2
90.5 : 08 : 1.5	15.8	17.7
90 :08 : 2.00	15.4	17.95



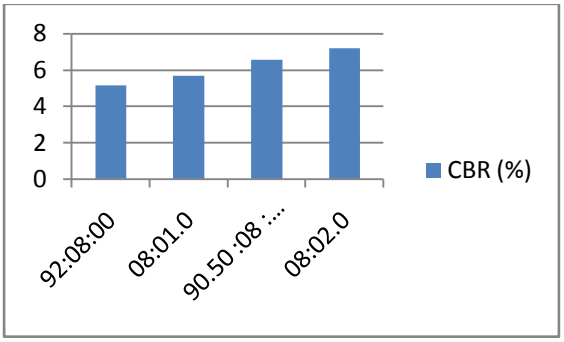
UNCONFINED COMPRESSIVE STRENGTH TEST

(Soil : ckd : pp Fibre)	UCS (kN/m^2)
91:08:1.00	185
90.5 : 08 : 1.50	204.6
90 : 08 : 2.00	230



CALIFORNIA BEARING RATIO TEST (SOAKED)

Proportion Soil : ckd : pp	CBR (%)
92:08:00	5.15
91 : 08 : 1.00	5.67
90.50 :08 : 1.50	6.56
90: 08 : 2.00	7.20



CONCLUSIONS

The conclusions drawn from the experimental investigation are as under:

- When percentage ckd 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 ckd to be used for further work was 11%..
- The best ratio obtained was 90% soil: 08% ckd: 2% pp fiber.
- Soaked CBR value increases from 2.66% for virgin soil to 7.20% for the best ratio of the mix.
- Unconfined compressive strength of soil-ckd mixtures increase with increase in pp fiber up to 2% by weight

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