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GEOTECHNICAL PROPERTIES OF FIBER REINFORCED POND ASH

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ABSTRACT –

In the recent past huge amount of Fly ash and Pond ash are generated by the thermal power plants. It is a major cause of concern for the people living around the power plants. The current rate of deposition of Pond ash in India has reached 170 million tons per annum. About 90,000 acres of precious land is used for the storage of abandoned Pond ash. But current rate of utilization of ash is only about 35-40%.The unused ash leads to an ever increasing pounding area for storing ash and related environmental issues for the people around the power plants.

Besides this, over the last few years, the construction of highways and roads has taken a boost. This requires a huge amount of natural soil and aggregates to excavate or to be deposited. Again this is an environmental issue and economical too. These are some issues now-a-days which motivates in development of alternative methods to overcome those environmental and also the economic issues. This leads to the reuse of suitable industrial byproducts which can fix those issues and also fulfill the specifications. Pond ash is one such byproduct. It is a non-plastic and lightweight material.

KEYWORDS –

Fly ash, thermal power plant, environmental issue, non plastic materials

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1. INTRODUCTION –

Thermal power plants release waste materials environment. Disposal of them is a major concern now-a-days. It requires a large area and also has many environmental issues. Major by-products are Fly ash, Bottom ash and Pond ash. Fly ash is collected from the flue gases of the power plants by mechanical or electrostatic precipitator. Bottom ash is collected from the bottom of the boilers. Pond ash is derived from the mixture of both fly ash and bottom ash. The power plants produce very large amount of pond ash as compared to fly ash and bottom ash. So the goal is to utilize the pond ash in some other fields to minimize its potential hazard to the environment.

As compared to the natural soil, the weight of pond ash is very less and it has self-draining capability. It is necessary to know the strength characteristics of pond ash before its successful application in various fields. During the construction of embankments, abutments, earthen dams and other retaining structures a huge amount of soil is needed. Due to rapid industrialization and the scarcity of availability of natural soil the scientists thought to utilize the waste products of power plants as a replacement to the natural soil. This will solve the environmental issues due to the deposition of the by-products and also reduce the scarcity of natural soil.

2. LITERATURE REVIEW

PAST STUDY:

Kumar et al. (1999) reported the results of laboratory tests conducted on pond ash & silty sand specimens with randomly distributed polyester fibers. The results showed that the use of fiber as a reinforcing material in soils increases the peak friction angle , peak compressive strength, CBR value, and ductility of the specimens. It also obtained that the pond ash & silty sand is approximately 0.3%- 0.4% of the dry density.

Bera et al. (2007) presented the effect of compaction on the strength characteristics of pond ash.The change in strength due to different compaction, controlling parameters, such as layer thickness, compaction energy, optimum fiber content to be used for both as by-products which are threat to tank size, moisture content, mould area, and specific gravity on the dry unit weight of pond ash are obtained. Same tests were carried out for three different types of pond ash.

Chand et al. (2007) presented how the lime stabilization affects the strength and durability aspects of pond ash. The lime constituent was as low as 1.12%. Subsequently lime contents of 10% - 14% were used, and the samples were cured with curing temperature of around 30°C for different curing periods of 28days, 45days, 90 and 180 days. Samples were subjected to rebound hammer test, unconfined compression test as well as point load strength test and slake durability test.

Ghosh et al. (2010) presented the laboratory test results of pond ash (unstabilized) and stabilized with different percentages of lime content of about 4%, 6%, and 10%) to determine the suitability of lime stabilized pond ash for base and sub-base construction of roads.

Jakka et al. (2010) studied the geotechnical characteristics of pond ash samples, sampled from the outflow and inflow points of two ash pond areas in India. Strength characteristics were obtained using CD (consolidated drained) and CU (consolidated undrained) triaxial tests with pore water pressure measurements, conducted on loose and compacted specimens of pond ash samples under different confining pressures

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Ash samples collected from the inflow point of ash pond area exhibited similar behaviour to sandy soils in many aspects

PRESENT STUDY:

From the past study it is pretty clear that several attempts have been made already by the researchers to understand the mechanism of fiber inclusions incorporated into pond ash to improve its geotechnical properties as well as strength by interacting with the pond ash particles mechanically through surface friction as well as by interlocking. However, the present study is an attempt that has been made to improve the geo-engineering properties of compacted pond ash using polyester fibre (Recron-3S) as the reinforcing material.

3. EXPERIMENTAL WORK

3.1 Introduction

Experiments were done to determine geotechnical characteristic of pond ash and change in the behavior of pond ash using Recron as a reinforcing material. Physical and chemical parameters of the pond ash were measured. After that engineering property of unreinforced pond ash was measured. Then same experiments were repeated by changing the percentage of fibre in pond ash.

3.2 Material used

1. **Pond ash**
2. **Recron 3s** as reinforcing material

3.2.1 Pond ash

Pond ash sample was collected from NSPCL, Rourkela. The sample passing through the sieve of 2mm dia was used in experiments.

3.2.1.1 Physical parameters of pond ash

Physical parameter of pond ash is represented in table 3.1

parameter	value
color	Light grey
shape	Sub-rounded
Uniformity coefficient	1.93
Coefficient of curvature	1.5
Plasticity Index	Non-Plastic

3.2.1.2 Chemical compositions

Chemical composition of pond ash is represented in table 3.2.

Parameter	Value in percentage
SiO_2	59-61
Al_2O_3	28-28.8
Fe_2O_3	2.70-5.52
Na_2O	0.24-0.50
K_2O	1.26-1.76
CaO	0.7-1
MgO	1.40-1.90
LOI	0.5-2.5

3.2.1 Recron 3S

Recron 3S is modified polyester. It is generally used as reinforcing material in concrete and soil to increase their performance. Recron 3S sample used in experiment was of size 12mm and manufactured by RIL.

3.2.1.1 Physical parameters of Recron 3S

Physical parameters of Recron 3S is represented in table 3.3.

Table 3.3 Physical parameters of Recron 3s

Parameter	Value
Cross section	depends
Diameter	35-40 micron
Elongation	>100%
Cut length	3mm,6mm,12mm
Melting point	240-260 C
Softening point	220 C
Specific gravity	1.34-1.40
Colour	white

(By ICC Evaluation Services Inc USA)

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3.3 List of experiments which are done:

1. Specific gravity of pond ash
2. Grain size analysis of pond ash
3. Compaction test
4. Direct shear test
5. Unconfined compression test
6. CBR test
7. Footing load test

3.3.1 Specific gravity test (IS 2720(III/SEC-I): 1980

The specific gravity of pond ash was determined by density bottle and illustrated in table 3.4.

Table 3.4 Observations for specific gravity test

Mass of bottle	99.04	103.17	120.9
Mass of bottle + soil	149.04	153.17	170.9
Mass of bottle + soil+ water	376.95	380.43	398.26
Mass of bottle +water	347.9	351.43	369.2
Specific gravity	2.38	2.38	2.38

3.3.2 Determination of grain size distribution (IS 2720(IV):1985)

Pond ash consists of both coarse and fine particles. Sieve analysis was carried out for coarse particle. Hydrometer method was applied to finer particle. Particle size distribution curve was plotted between percent finer vs. particle size. Coefficient of uniformity and co-efficient of curvature were found out using the following formula.

Coefficient of uniformity, $C_u = D_{60} / D_{10}$
Coefficient of curvature, $C_v = (D_{30})^2 / (D_{60} * D_{10})$

4. GRAPHS AND RESULTS

4.1 Index Properties:

4.1.1 Specific gravity:

The Specific gravity of pond ash was found to be 2.38.

4.1.2 Liquid limit:

Liquid limit is the minimum water content at which soil is in liquid state but possesses small shear strength against flowing. As the pond ash is non plastic, the liquid limit can't be found out.

4.1.3 Plastic limit:

Plastic limit is the minimum water content at which soil begin to crumble when it is rolled into a 3mm dia thread. Due to non plastic nature of pond ash, plastic limit can't be found out.

4.1.4 Grain size distribution

Grain size distribution curve was determined by sieving and hydrometer analysis. Grain size distribution curve is represented in figure 4.1. The coefficient of curvature and coefficient of curvature were found to be 1.93 and 1.5 respectively.

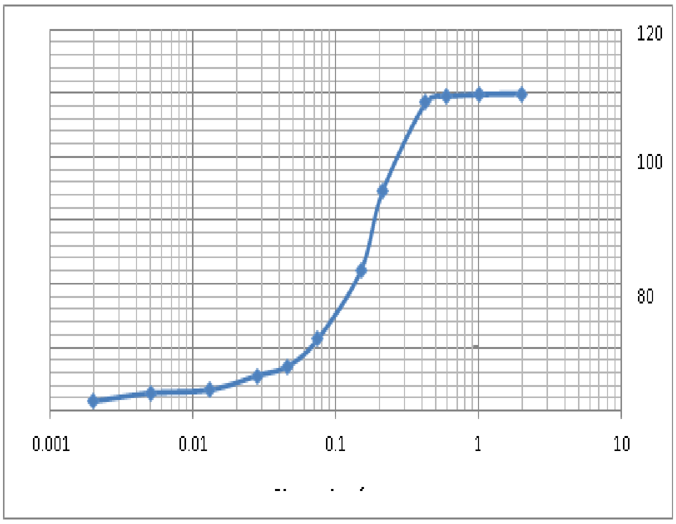

Fig 4.1.4. Grain size distribution curve

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4.2 Engineering Properties:

4.2.1 Compaction test

Compaction tests were carried out at different compaction energy (595kJ, 893.6kJ, 2139.2 kJ and 2674kJ) and corresponding MDD and OMC were found out. In experiment we can see the dry density increases with increase in moisture content up to achieve MDD. Further addition of water decreases the dry density. Results are shown in table. Maximum dry density of pond ash is increasing with increase in compaction energy where as optimum moisture content is decreasing with increase in compaction energy. Figure 4.2 to 4.5 shows the graph related to compaction test.

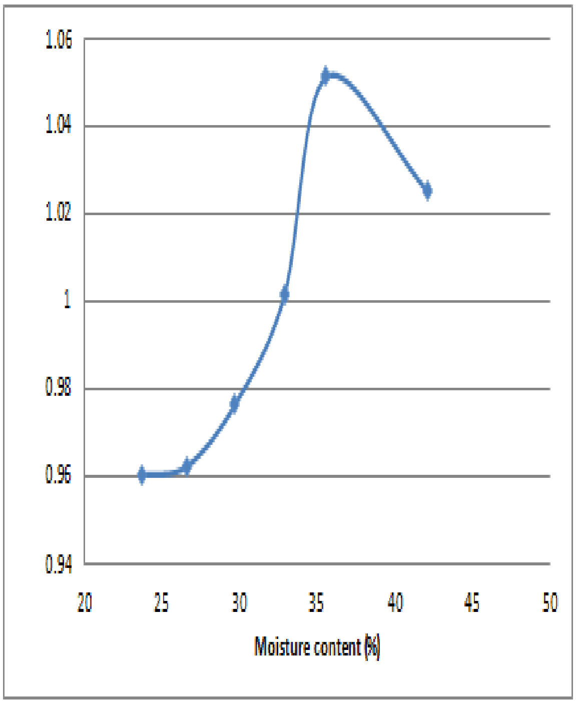

Fig4.2.1.1 Variation of dry density with moisture content at compaction energy 595kJ/m^3

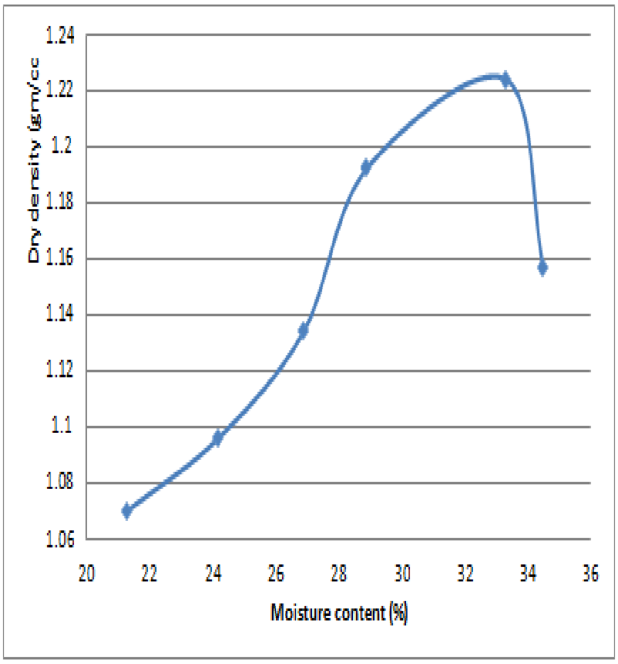

Fig4.2.1.2 Variation of dry density with moisture content at compaction energy 2674kJ/m^3

4.2.2 Direct shear test

Direct shear test was conducted for unreinforced pond ash at MDD and OMC corresponding to light compaction test and heavy compaction test. Shear parameters were determined from the graph between normal stress vs. shear stress.

Then the same test was carried out by changing the percentage of fibre (0.2%-1%) in pond ash and shear parameters were determined by same process. Results are shown in table 3.6 and 3.7. Figure 4.6 to 4.9

Show the graph related to direct shear test. The value of Shear parameters are increasing with increase in percentage of fibre in pond ash. When the soil was compacted at light compaction density and moisture content, the unit cohesion and angle of friction vary from 0.163-0.3 kg.cm2 and 31.38-33.82 with change in percentage of reinforcement from 0-1%. In case of heavy compaction density and moisture content unit cohesion and angle of friction vary from 0.19-0.33 and

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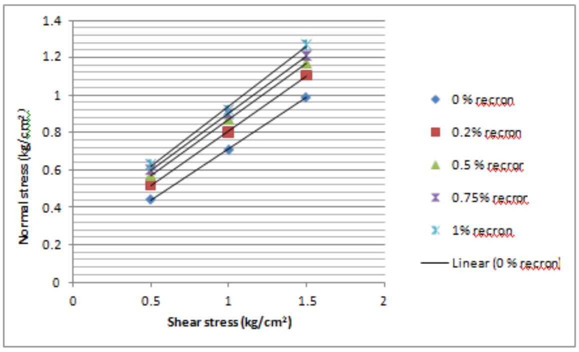
30.11-38.0 with change in percentage of reinforcement from 0-1 %.



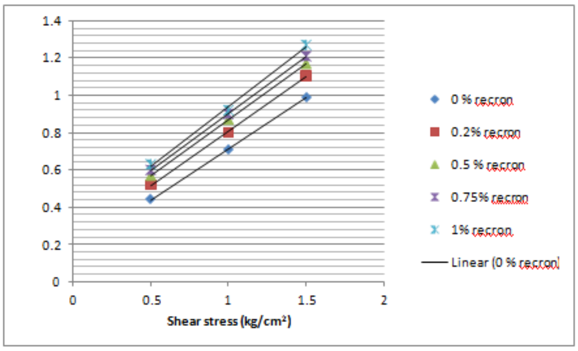


Figure 4.2.2.1 Normal stress vs. Shear stress (light compaction MDD and OMC)

5. CONCLUSIONS:

- The specific gravity of pond ash is 2.38. This property helps in building light embankments over soft soil.
- Particle size distribution curve represents a well graded soil. Generally contains fine sand particles and silt particles.
- Pond ash is non plastic in nature so atterburgs limit can't be determined.
- Maximum dry density varies from 1.054gm/cc to 1.225gm/cc with change in compactive effort from 595kJ/m^3 to 2674kJ/m^3.
- Optimum moisture content varies from 38.8% to 33.6% with change in compactive effort from 595 kJ/m^3 to 2674 kJ/m^3.
- Increase in compaction energy increases the maximum dry density.
- However MDD is not linearly dependent to compaction energy.
- Increase in compaction energy decreases the optimum moisture content.
- Cohesion value and angle of friction increases with increase in percentage of fibre content in pond ash.
- Cohesion value increased up to 76 % and with change in percentage of fiber from 0 to 1 % at light compaction MDD and OMC.
- Cohesion value increased up to 82% with change in percentage of fiber from 0 to 1 % at heavy compaction MDD and OMC.
- Cohesion value is not linearly dependent to change in percentage of fibre. The increase in cohesion value at fiber content 0-0.5% is more than fiber content 0.5- 1%.
- Angle of friction is not much affected by reinforcement.
- UCS value of pond ash increases with increase in percentage of fiber content in pond ash.
- UCS value increased from 0.23 kg/cm^2 to 0.42 kg/cm^2 with change in percentage of fiber content from 0 to 1 % at light compaction MDD and OMC.
- UCS value increased from 0.36 kg/cm^2 to 0.54 kg/cm^2 with change in percentage of fiber from 0 to 1 % at heavy compaction MDD and OMC.
- The increase in UCS is non- linear with respect to fibre content.
- The ductility characteristic was increased by using fiber.
- Unsoaked CBR value of unreinforced soil compacted at light compaction MDD and OMC found to be 10.38%. Unsoaked CBR value was increased up to 28.9% by increasing the fiber content to 1 %.
- Unsoaked CBR value of unreinforced soil compacted at heavy compaction MDD and OMC found to be 19.38%. CBR value was increased up to 38.7% by increasing the fiber content to 1 %.

- The rate of increment of Unsoaked CBR value is not linear with fiber content.
- Unsoaked CBR value corresponding 2.5mm penetration is always greater than 5mm penetration.
- Reinforced pond ash can be used for sub base as its Unsoaked CBR value is more.
- Ultimate bearing capacity of pond ash was increased with increase in degree of saturation up to 83.93 %, and then decreased.
  Reinforced pond ash shows good engineering properties as conventional earth material. So pond ash can replace the conventional earth material in some of the geotechnical constructions.

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