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Research Paper

"Geotechnical Behavior of soil with Fiber Reinforced Pond Ash"

Kamlesh Kumar Chandrakar [1] Gopesh Kumar Dawda [2] Madhu Sahu[3] Gayatri Thite[4]

Raipur Institute of Technology, Raipur, Civil Engineerig, CSVTU, Bhilai(C.G.), Mandirhasoud, Raipur, India

Email address: kamleshchandrakar1606@gmail.com, gopeshdawda91@gmail.com, madhusahu952809@gmail.com, gayatri28thite@gmail.com

**Corresponding Author:* kamleshchandrakar1606@gmail.com

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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 rate of pond ash deposition in India is 170 million tons per year, with 90,000 acres of land used for storage. However, the current utilization rate is only 35–40%, leading to an increasing ponding area and environmental issues. The construction of highways and roads has also increased the need for natural soil and aggregates, further causing environmental and economic issues. To address these issues, alternative methods have been developed, such as using suitable industrial by-products like pond ash, which is a non-plastic and lightweight material. Pond ash is collected from the Siltara power plant. During this work, the pond ash is replaced partially with soil by 10%, 20% and 30%. The co- efficient of uniformity and co-efficient of curvature of soil is analyzed by sieve analysis of new composition of soil. Also specific gravity of soil with fiber reinforced pond ash is analyzed by pycnometer method and to determine the optimum moisture content of soil. In this case the soil is replaced with pond ash by 10%, 20% and 30% partially with addition of coconut fibers of volume of fraction of 0.5 and 1.0%. These results will be very much helpful for the successful application of pond ash in different fields such as embankment construction, road base and sub-base construction, designing of retaining walls etc., as well as the disposal of pond ash in an eco-friendly manner.

Keywords – Fly Ash, Pond ash, Power plant, Reuse, Replacement, Specific gravity, Coefficient of curvature, Application.

II. Introduction

Thermal power facilities generate by products such as fly ash, bottom ash, and pond ash, which pose environmental problems. The large volume of pond ash produced by thermal power plant makes it difficult to maximize its use. Pond ash, on the other hand, has potential application in civil engineering works, like structural fills and highway embankments. It is lightweight and self-draining, making it an ideal fill material. Understanding the compaction characteristics of pond ash is essential for successful application. Pond ash, with its low weight and self-draining capability, is being explored for its potential applications in construction of dams, embankments, and abutments. Due to industrialization and soil scarcity, scientists are considering using power plant waste as a replacement for natural soil.

Geotechnical constructions like embankments and retaining walls require large amounts of earth materials, and rapid industrialization has led to the use of waste products like pond ash. Pond ash, a by-product of coal-fired thermal power plants, contains fine sand to silt particles. Research has been conducted to determine its suitability for construction, but it is difficult to preserve its inherent strength in field situations. The physical, geotechnical, and chemical parameters for pond ash are similar to those for natural soils [1]. However, only 35% of pond ash is commercially used in India, highlighting the need to maximize its use to preserve natural soil.

II. Materials used

Pond ash-is the product of combination of Fly ash, Bottom ash and coal which are by products of thermal power plants [2]. Together these are mixed with water to form slurry. That slurry is pumped to the ash pond. In ash pond area, excess water is removed and the ash settles as residue. This residual deposit is called pond ash. This is used as filling materials including in during construction of roads, dams & embankments, pond ash is used as a filler material. Some special type of pond ash is used for manufacturing of building materials like lime fly ash bricks/ blocks etc. Thermal power plants contribute a major quantity of pond ash. Besides this aluminium, steel, and copper plants also produce a substantial amount of pond ash.

Reinforcing Fibres-

- Fibres are the load-carrying constituents of composites and occupy the largest volume in a composite laminate.
- Fibre strength is the highest along the longitudinal direction and lowest in the transverse direction.
- Fibres can be continuous of discontinuous. The strength and modulus of composites produced from continuous fibres are greater than those produced from discontinuous fibres.
- A single continuous fibre is called a filament and it has extremely small diameter, which makes it difficult to handle for practical purposes.
- To obviate this difficulty, a large number of filaments are gathered together into a bundle to produce a commercial form called a strand. The average tensile strength and modulus of fibre strands are smaller than those of single filaments [3].

Types of Fibres:

Fibres are divided into two categories mainly. They are

(a) Natural (b) Man-made

(a) Natural Fibre: These types of fibres include coir, cotton, sisal, any type of animal hair etc. The following advantages of natural fibre are enlisted below-

(i) Coir & Jute are abundantly available in India.

(ii) Production cost is less. When used for erosion control, saves useful topsoil

(iii) Hard, strong and require no pre-treatment.

(iv) Extensive use where temporary reinforcement is required.

(v) Being an eco-friendly product, natural fibres, can be used for sustainable development of infrastructure.

(b) Man-made fibre: It includes carbon fibre, polyester, glass fibre, polyvinyl, acrylic etc. The following advantages of manmade fibre are enlisted below-

(i) Cheaper to produce.

(ii) Stronger.

(iii) More resistant to rot.

(iv) Can be made continuous in any length.

(v) Can be made to float.

Coconut Fibre:

The adaptability of coconut fibers and their uses in many engineering fields—particularly as a building material in civil engineering—are discussed in this study. One of the naturally occurring fibers that is widely available in tropical areas is coconut fiber, which is taken from the coconut fruit's husk. The qualities of composites (cement pastes, mortar, and/or concrete, etc.) in which coconut fibers are utilized as reinforcement are discussed as well in addition to the physical, chemical, and mechanical properties of coconut fibers. A brief presentation is also made on the studies conducted and the findings reached by various researchers over the past few decades. This document also includes graphs illustrating the relationships between various attributes. Composites reinforced with coconut fibers have been employed as affordable, long-lasting non-structural element.

Properties of Coconut Fibres-

A comparison of the tensile strengths of the coconut fibers described reveals significant differences in some aspects, such as diameter, which is almost the same, and tensile strength magnitudes, which differ significantly. Additionally, the range given for a specific property—which mentions the density of coconut fiber as 0.67–10.0 g/cm—is rather broad. These figures are implausible; actual values could be between 0.67 and 1.00 g/cm3.

Coconut fibers have different qualities, which makes it challenging to use them frequently as building materials. Although gathering data on fiber characteristics is intended to serve as a guide, a significant amount of variation is observed once the data is compiled.

III. Methodology

This thesis is performed to determine various properties of Fibre reinforced pond ash soil by different test [4]. For the determination we have proportionate the pond ash and fibres with soil in the ratio of P-10 F-0.5%, P-10 F-1%, P-20 F-0.5%, P-20 F-1%, P-30 F-0.5% & P-30 F-1%.

i) Specific Gravity- Specific gravity is the ratio of the mass of unit volume of soil at a stated temperature to the mass of the same volume of gas-free distilled water at a stated temperature.

$$\mathbf{G} = Y_s/Y_w$$

Pycnometer Method- Specific gravity of soil by using a pycnometer. This is a quick method of determining the water content of those soils whose specific gravity G is accurately known Pycnometer is a large size density bottle of about 900ml capacity. A conical brass cap, having a 6 mm diameter hole at its top is screwed to the open end of the pycnometer. A rubber washer is placed between conical cap and the rim of the bottle so that there is no leakage of water.

Calculation:

The specific gravity G of the soil = (W2-W1) / [(W2-W1)-(W3-W4)]

W1=Wt. of empty pycnometer

W2=Wt. of pycnometer + material (soil + fibre + pond ash)

W3=Wt. of pycnometer+ material + water

W4=Wt. of pycnometer + water

(ii) Particle size distribution: The distribution of different grain sizes affects the engineering properties of soil. Grain size analysis provides the grain size distribution, and it is required in classifying the soil.

Sieve Analysis: The process of sieve analysis involves vibrating a soil sample through a series of sieves with progressively smaller openings. The soil is first dried in an oven, and then every lump is broken up into tiny pieces before being put through the sieves. The amount of soil held in each sieve is measured once the shaking phase has ended.

Calculation:

Percentage retained on any sieve = Wt. of soil retained /Total wt. of soil x 100

Cumulative percentage retained on any sieve = Sum of Percentage retained.

Percentage finer than sieve size = 100% - sum of percentage retained.

(iii)Compaction Test: The purpose of the laboratory compaction test is to determine the proper amount of water at which the weight of the soil grains in a unit volume of the compacted soil mass is maximum [5]. The amount of water thus calculated is called the optimum moisture content. In the laboratory, the different value of the moisture content and resulting dry density is obtained after compaction or plotted both to arithmetic scale, the former abscissa and the latter as ordinate. The purpose of the test is to determine the optimum moisture content of the soil by using standard proctor test [6].

Standard Proctor Test:

Mechanical compaction is one of the most common and cost effective means of stabilizing soils [7]. An extremely important task of geotechnical engineers is the performance and analysis of field control tests to assure that compacted fills are meeting the prescribed design specifications.

Optimum Moisture Content: Optimum moisture content is defined as the water content corresponding to the maximum dry unit weight or maximum dry density is known as optimum moisture content.

$$Y = w_1 - w_2 / v$$

Where, W1= weight of mould with moist compacted soil

W2= weight of empty mould

V = volume of the mould

The dry density (Y_d) of the soil shall be computed as follows:

$$Y_d = Y / 1+w$$

Where, Y = wet density of compacted soil

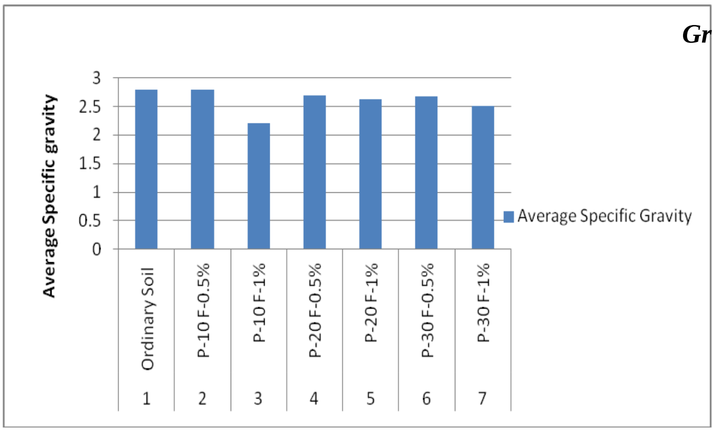
W = moisture content in percent

IV. Result and Discussion

(i) Specific Gravity

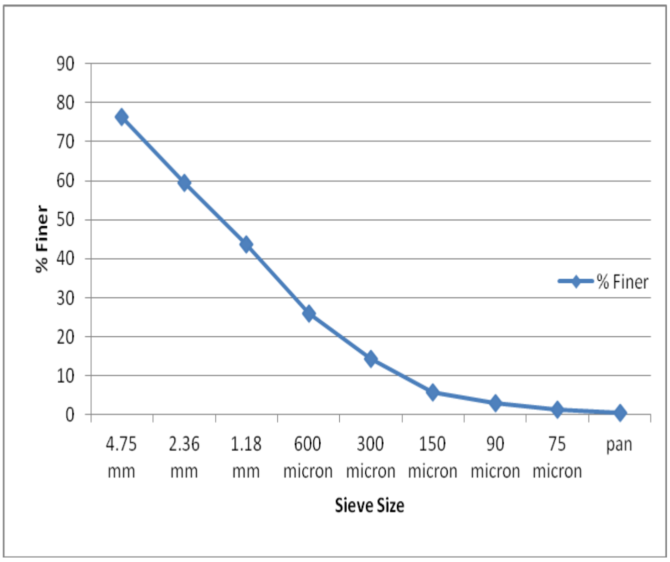
S.N.	Soil Composition	Average Specific Gravity
1	Ordinary Soil	2.8
2	P-10 F-0.5%	2.8
3	P-10 F-1%	2.21
4	P-20 F-0.5%	2.69
5	P-20 F-1%	2.63
6	P-30 F-0.5%	2.68
7	P-30 F-1%	2.5

Graph- Specific gravity test by pycnometer

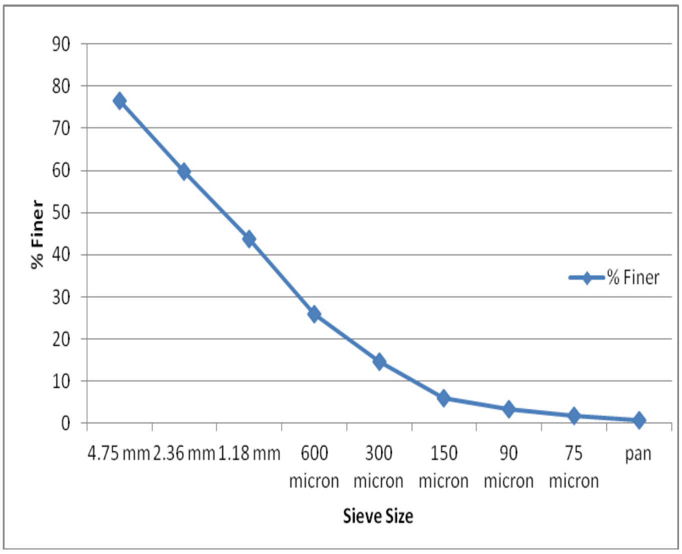


(ii) Sieve Analysis

Graph- particle size distribution for ordinary soil

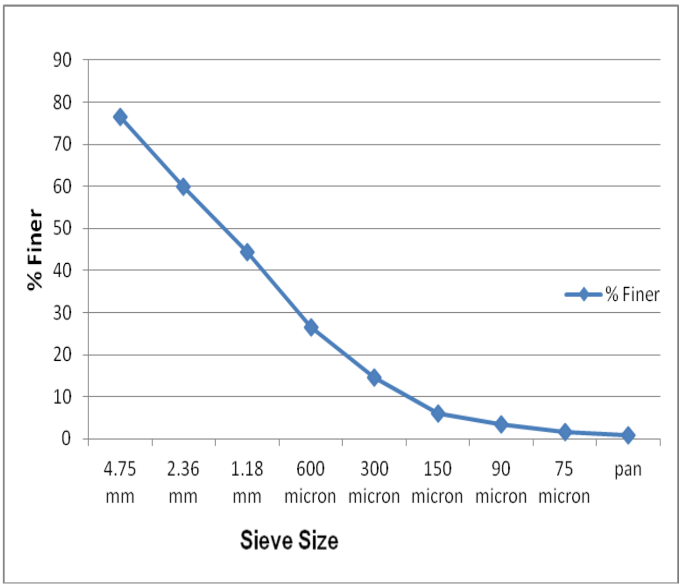


Graph- particle size distribution for **soil +10 % pond ash**

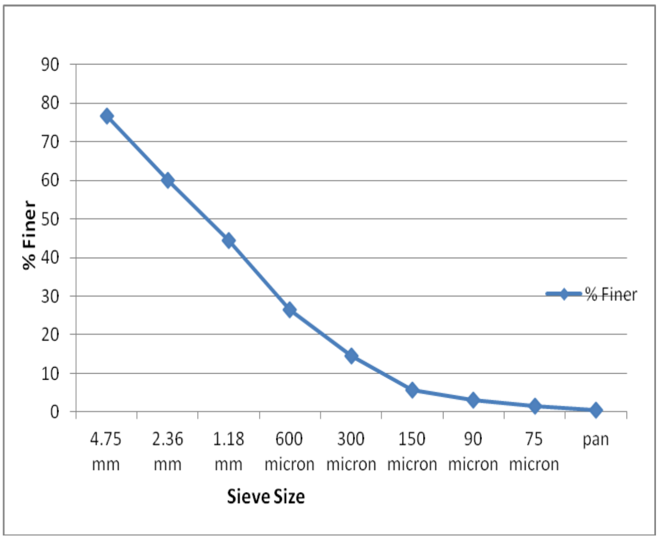


Graph- particle size distribution for **soil +20 % pond ash**

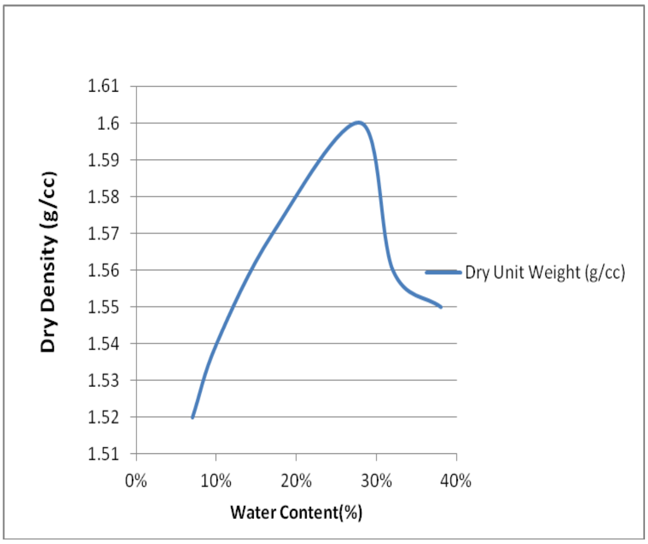
For ordinary soil		soil +10 % pond ash		soil +20 % pond ash		soil + 30 % pond ash	
Sieve No.	% Finer	Sieve No.	% Finer	Sieve No.	% Finer	Sieve No.	% Finer
4.75 mm	76.4	4.75 mm	76.52	4.75 mm	76.6	4.75 mm	76.67
2.36 mm	59.5	2.36 mm	59.64	2.36 mm	59.8	2.36 mm	59.91
1.18 mm	43.8	1.18 mm	43.76	1.18 mm	44.3	1.18 mm	44.35
600 micron	26	600 micron	26.02	600 micron	26.4	600 micron	26.39
300 micron	14.4	300 micron	14.54	300 micron	14.6	300 micron	14.51
150 micron	5.76	150 micron	5.98	150 micron	6	150 micron	5.81
90 micron	3.06	90 micron	3.38	90 micron	3.38	90 micron	3.13
75 micron	1.26	75 micron	1.68	75 micron	1.74	75 micron	1.53
pan	0.56	pan	0.84	pan	0.86	pan	0.63



Graph- particle size distribution for **soil +30 % pond ash**



(ii) Compaction Test



V. Conclusion

It is concluded that:

(1) Addition of pond ash and fiber in ordinary soil in any proportion, the results are nearly same to 2.65 (standard specific gravity).

(2) Due to soil loss in sieve analysis test, error up to 5% is considered.

(3) It has also been observed that when the content of the fiber is been increased in the mixture of ordinary soil and pond ash, the specific gravity of the mixture decreases.

(4) In optimum moisture content test, it is been observed that the dry density of the soil increases with increase in the percentage of pond ash and fiber.

(5) As percentage of pond ash increases in dry soil, both optimum moisture content and dry density increases.

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