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Effect on Geotechnical Properties of Pond Ash with Variation of Compactive Energy

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ABSTRACT: With the increase in the number of coal based thermal power plants in India, generation of coal ash has reached enormous proportions. India at present produces around 120 Million tonnes of Ash per annum. The power requirements of the country are rapidly increasing with increase in growth of the industrial sectors. India depends on Thermal power as its main source (around 80% of power produced is thermal power), as a result the quantity of Ash produced shall also increase. Indian coal on an average has 35 % Ash and this is one of the prime factors which shall lead to increased ash production and hence, Ash utilization problems for the country. Out of the total ash produced. Fly ash contributes to a small percentage, majority being Pond ash and bottom ash. Ash disposal involves design and installation of ash ponds, which in addition to covering quite large area at each plant site, creates aesthetic as well as hygienic environmental impacts. This has warranted the scientific and industrial community to initiate research and development work for finding avenues for the innovative use and safe disposal of the pond ash so that instead of a waste product, the pond ash could be considered as a usable by-product. Though a lot of research has been carried out for the effective utilization of pond ash like its use in construction industry etc, little literature is available on pond ash utilization particularly its use as a foundation material. One way of disposing off pond ash would be its use as a structural fill material and use as embankment material in highways. The present work aims at evaluating the response of pond ash to various compactive efforts. The compactive efforts have been varied as 595 kg/m^3 to 2674 kg/m^3 of sample and effect of compaction energy on maximum dry density and optimum moisture content have been evaluated by conducting proctor compaction tests, the shear strength parameters of pond ash samples compacted to different dry densities and moisture contents.

Keywords: -Pond Ash, Compaction Energy, Stress, Strain, UCS.

I. INTRODUCTION

Wastes are generated more and more with increasing industrialization and population growth. Based on the safety level, these wastes can be controlled by different options such as waste reduction, separation and recycling, resources, recovery through waste processing, waste transformation, and environmentally sustainable disposal on land. The most frequently used disposal option for solid waste in the landfill because of its low cost and efficiency. The core component of a waste disposal facility is its liner system. The design of liner is made so. as to isolate the waste from the environment minimizing the passage of leachate into the groundwater. To ensure this the important characteristics for compacted landfill liners are selection of materials, hydraulic conductivity and strength. Usually, soil rich in clay minerals are used as compacted liner materials for their low hydraulic conductivity which is required to be less than 1.0×10^{-7} cm/s Instead of clay, mixture of expansive soil such as fly ash and pond ash can is used as compacted barriers.

In India, thermal power is the chief source of energy and produces nearly 70 percent for total energy production. The coal ash generated from all the existing thermal power plant is over 100 million tonnes per year. Since the production of high ash content and low percentage utilization, most of the fly ash has to suitably disposeof on land by creating an engineering ash pond to take care of environmental concerns. The fly ash as well as bottom ash produced by the plant is generally disposed of in an ash pond in a form of slurry in a ratio varying from 1 part ash and 6 to 10 parts of water which are located within few kilometres distance from the power plant. This ash is called pond ash. The existing 70 thermal power plants alone need 40,000 hectares of precious land for disposal of fly ash in their life span of 30 years (Murthy, 1998). Roughly, 2% of the cost of thermal power plant is invested towards flyash disposal systems. In the existing thermal power stations, around Rs.700 crores have been invested for flyash disposal, whereas similar investment would have been sufficient to convert all the flyash into useful products. A number of road and highway projects which are being planned under the auspices of National Highway Authority of India (NHAI), Ministry of surface Transport (MOST) or state PWDs have potential to consume enormous quantity of flyash in embankments, base and pavement courses.

According to Central Electricity authority of India, there are around 83 major coal fired thermal power plants and 305 hydro plants existing in India. As per the ministry of power statistics, the total installed generating capacity (Thermal + wind) during 2003-2004 was about 79838 MW and hydropower generation was 29500 MW. In addition to this, there are more than 1800 selected industrial units which had captive thermal power plants of >1MW. Over 75% of the total installed power generation is coal-based,230 - 250 million MT coal is being used every year, High ash contents varying from 30 to 50%, More than 110 million MT of ash generated every year, Ash generation likely to reach 170 million MT by 2010, Presently 65,000 acres of land occupied by ash ponds and Presently as per the Ministry Of Environment & Forest Figures, 30% of Ash. Some of the prominent Power Plants which are also producing and providing good quality Fly Ash include the following:Ropar, Kota, Annapara, Dadri, Rihand, Singrauli, Unchahar, Chandrapur, Dahanu, Trombay, Vindyanchal, Raichur,Ramagundam.

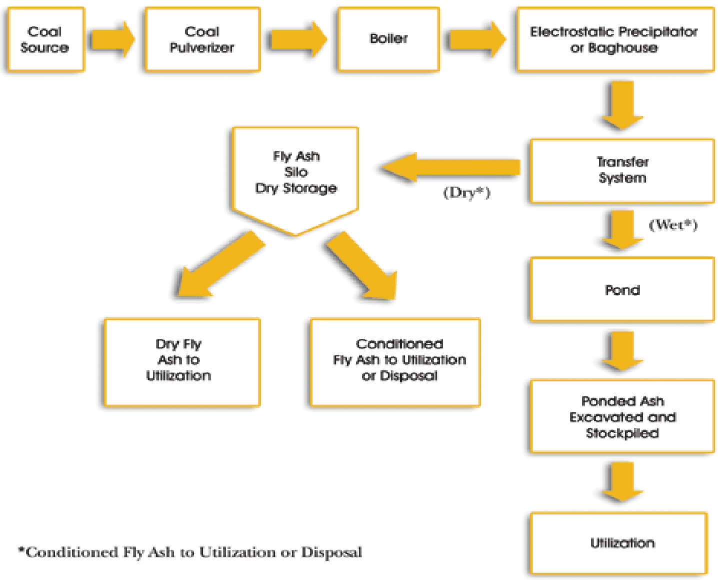

Fig. 1: Types of Ash

Pond ash consists of often hollow spheres of silicon, aluminum and iron oxides and unoxidized carbon. ASTM C618 Defines two major classes of Pond ash class C and class F. The former is produced from burning anthracite or bituminous coal and the latter is produced from burning lignite and sub bituminous coal. Both the classes of pond ash are puzzoolans, which are defined as siliceous and aluminous materials. Primary difference between Class C and Class F pond ash is the amount of calcium, silica, alumina, alumina, and iron content in the ash. Thus, pond ash can provide an array of divalent and trivalent cations (Ca2+ Al3+Fe3+etc) under ionized conditions that can promote flocculation of dispersed clay particles. Thus, expansive soils can be potentially stabilized effectively by caution exchange using pond ash.Fly ash and bottom ash are mixed together with water to form slurry, which is pumped to the ash pond area. In ash pond area, ash gets settled and excess water is decanted. This deposited ash is called pond ash. This is used as filling materials including in the construction of roads & embankments. Selected pond ash can be used for manufacturer of building products like lime fly ash bricks/ blocks etc.

This experimental work presents the study on compaction characteristics and shear parameters of pond ash. Under this work a number of experiments have been done to study the above. The effects of different compaction and shear controlling parameters, viz. compaction energy, moisture content, dry density is highlighted herein. The maximum dry density and optimum moisture content of pond ash vary within the range of 1.09 gm/cc- 1.27 gm/cc and 28%-39% respectively. In the present investigation, the degree of saturation at optimum moisture content of pond ash has been found to vary within the range of 72-8. Graphs have been plotted and conclusions have been extracted.

II. ENGINEERING PROPERTIES OF POND ASH

A. Compaction Behavior

The maximum dry density of compacted ash ranges from 12-19 kN/m³ and optimum moisture content vary between 15-30%. However, dry densities as low as 7 kN/m³ and optimum moisture content as high as 60% are reported in the literature (Hausmann, 1990). Dry density of Pond ashes is less sensitive to water content. Compacted pond ash is less compressible.

B. Shear Strength

It is one of the important properties of Pond ash when it is used as embankment material. Shear strength tests on freshly compacted flyash specimens at various water contents indicate that most of its shear strength is from angle of internal friction and exhibits some apparent cohesion which vanishes when samples are saturated (Sivapullaiah, 2001). The shear strength obtained was compared well with silt or loosely compacted fine sand. Strength values for fine pond ash are higher than those determined for coarse ash. This is believed to reflect the difference in capillary tensions between the coarse and fine ash samples (Leonards, 1982).

Pond ash in a moist but unsaturated condition display an apparent cohesion due to the tension of the retained capillary water but this cannot be relied upon for long term stability analysis and concluded that the strength property of major interest is angle of shearing resistance. Most of the pond ashes show an effective angle of shearing resistance of about 32-35 which is a typical value of loose sand.

C. Permeability

The permeability of Pond ashes is considerably high and lies in a narrow range and dissipation of the pore pressure will be quicker. Any small variation in permeability of Pond ash is not likely to adversely affect its use for most of the geotechnical applications.

III. LABORATORY EXPERMENTATION

The following tests were conducted on the soil. The index and engineering properties of soil were determined.

1. Compaction Test (IS: 2720- Part 8: 1983)
2. Unconfined Compression Test (IS 2720-10-Part 10:1973)
3. Direct Shear Test Confirming (IS: 2720 (Part-13) - 1986

Details of the laboratory experimentation carried-out with POND ASH have been discussed. And detailed discussions on the results obtained from various laboratories were presented.

A. Compaction Characteristics

The moisture content, dry density relationships were found by using compaction tests as per IS: 4332 (part III). For this test pond ash was mixed with water and the mixture was compacted in proctor mould. Compactive energy used was in the range from 0.3639-3.5554 kN-m. Fig 2 to 7 shows the effect of compactive energy on compaction characteristics.

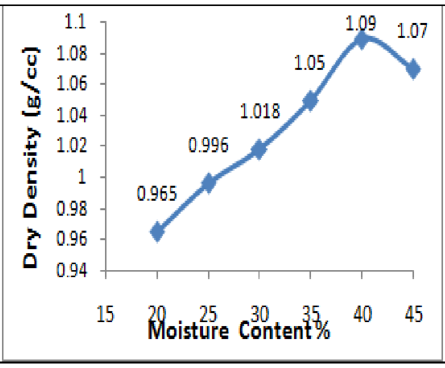

Fig 2 Compactive Energy 0.3639(kN-m)

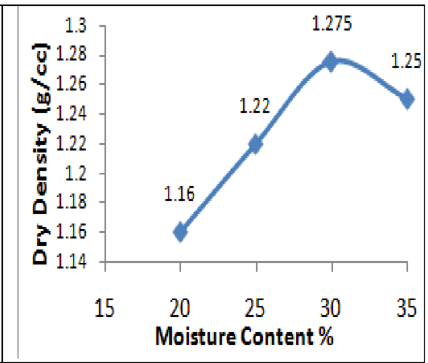

Fig 3 Compactive Energy 3.5554 (kN-m)

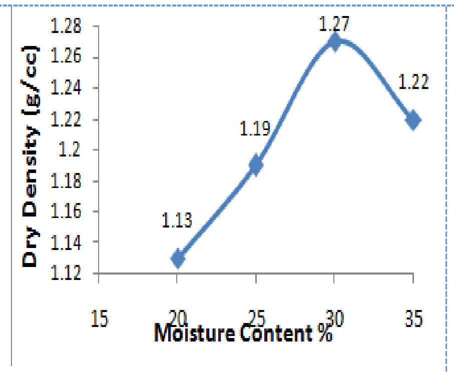

Fig 4 Compactive Energy 2.8444 (kN-m)

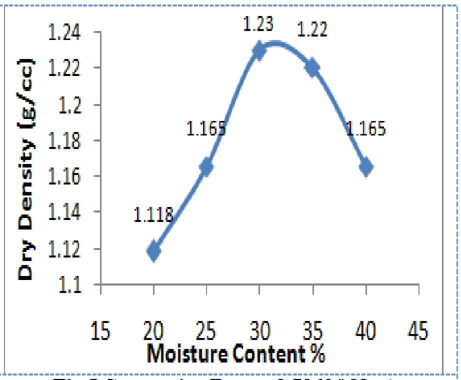

Fig 5 Compactive Energy 2.7260(kN-m)

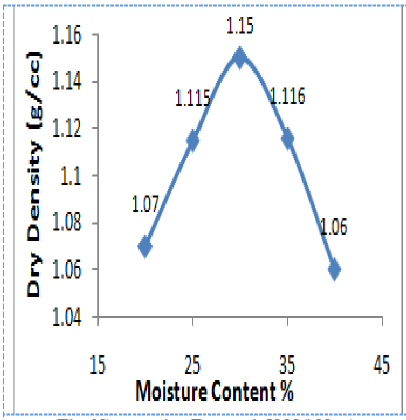

Fig 6Compactive Energy 1.5223(kN-m)

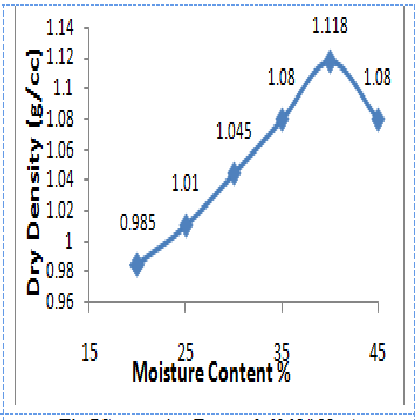

Fig 7Compactive Energy 0.6065(kN-m)

B. Unconfined Compression Test

Unconfined compression tests were performed on unreinforced specimens according to IS: 2720 (Part 2). Cylindrical specimens with a height to diameter ratio of 2 (100 mm high × 50 mm diameter) were compressed until failure. Compressive strength was found for different compactive efforts and different moisture content and fixed density and vice versa. The Variation of compressive strength with different compactive energies are shown in the Figs.8 to 13. From the below figures it is observed that as the compactive energy increases the stress increases at a constant strain.

Compressive Strength (Varied with Different Compactive Efforts)

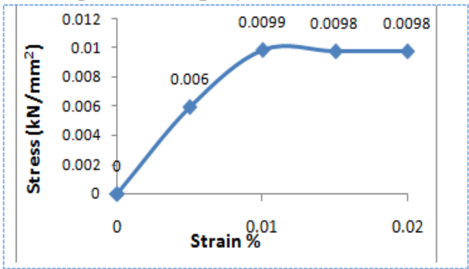

Fig. 8: Compactive Energy 3.5554 (kN-m)

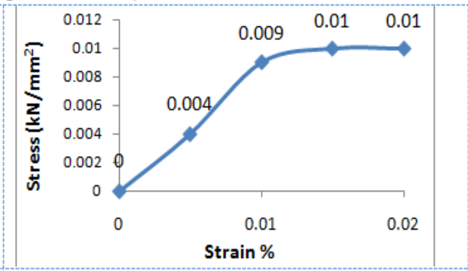

Fig 9: Compactive Energy 2.8444(kN-m)

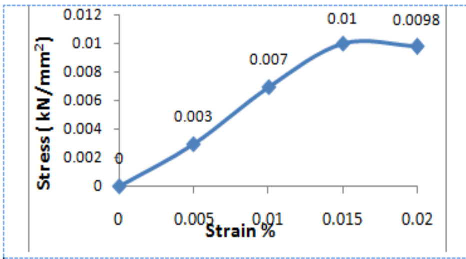

Fig.10: Compactive Energy 2.7260(kN-m)

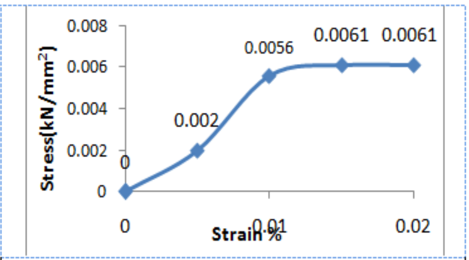

Fig.11 Compactive Energy 1.5223(kN-m)

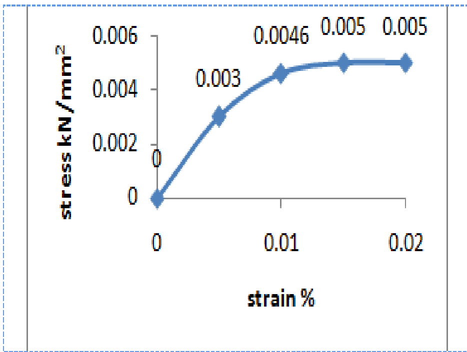

Fig.12 Compactive Energy 0.6065(kN-m)

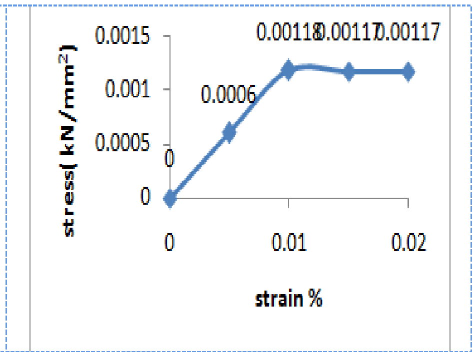

Fig.13 Compactive Energy 0.3639(kN-m)

C Compressive Strength Varied with Different Moisture Content and Fixed MDD

The maximum dry density of compacted ash ranges from 12-19 kN/m³ and optimum moisture content vary between 15-30%. However, dry densities as low as 7 kN/m³ and optimum moisture content as high as 60% are reported in the literature (Hausmann, 1990). Dry density of Pond ashes is less sensitive to water content. Compacted pond ash is less compressible.MDD Fixed:Standard proctor (OMC = 35.91% MDD= 1.1gm/cc)

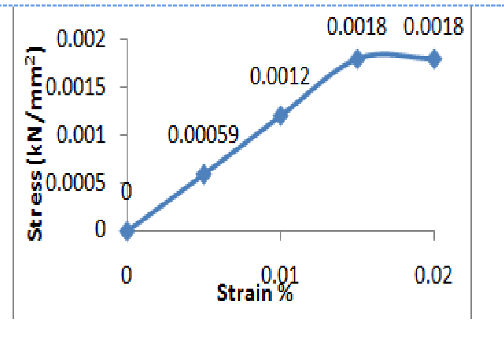

Fig. 14: Moisture Content = 45.91%

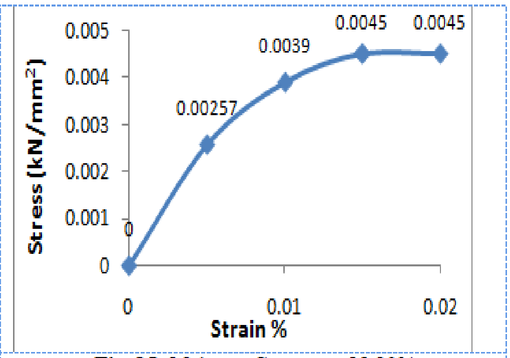

Fig. 15: Moisture Content = 38.30%

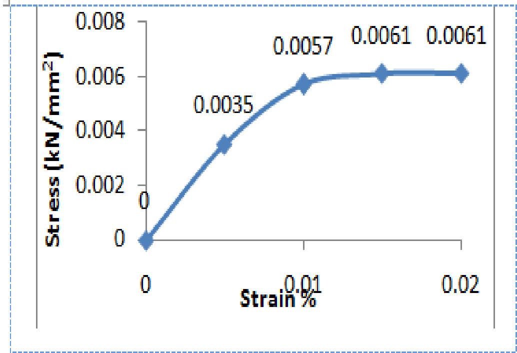

Fig. 16: Moisture Content = 25.91%

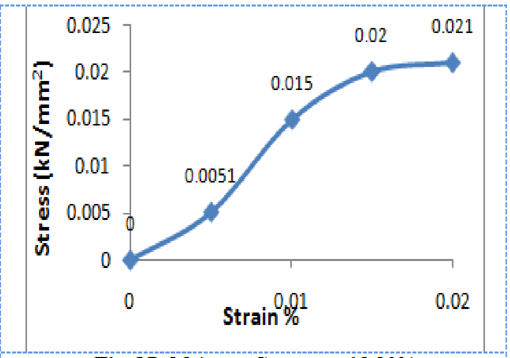

Fig. 17: Moisture Content = 18.30%

MDD Fixed

Modified proctor (OMC = 28.30%, MDD = 1.24gm/cc)

IV. CONCLUSIONS

MDD ranges from 1.09 gm/cc to 1.27 gm/cc. OMC ranges from 28% to 39%. Cohesion value ranges from 0.001kg/cm^2 to 0.153 kg/cm^2**.** Compressive strength ranges from 0.0112 kg/cm^2 to 0.25 kg/cm^2.As increase in amount of compaction energy results in closer packing of pond ash particles hence there is increase in dry density MDD increases with increase in compaction energy. From results it is observed that with increase in compaction energy, OMC decreases. Relationship between unconfined compressive strength and MDD is almost linear. Relationship between unconfined compressive strength and compaction energy is linear. Due to increase in compaction energy the density of pond ash increases which follows increases in unconfined compressive strength and it also depends on moisture content.

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