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COMPARISON STUDY OF GEOTECHNICAL BEHAVIOUR OF SAND, POND ASH AND FIBERS UNDER LOADING

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ABSTRACT

In coal-fired power producers coal is majorly used in production. It was utilized for charging in the furnace boilers in the form of cones. These the lumps were usually immersed continuously in a moving gate. With the rise in temperature, the ash takes on a molten form. After chilling, it turns into cinder containing little ash. It has been proven as power saver. Global production of lake ash is growing every year. Both in disposal, and in practice, appropriate measures should be taken to protect the person life, wildlife and nature. Accordingly, a study was conducted for different combinations of sand, pond ash along with fibers encapsulated into the geo fiber sheet were subjected to different overburden pressures and were tested for varied permeability conditions.

1. INTRODUCTION

In geotechnical engineering, the properties of soils at a given site may be less than ideal and can potentially cause damage to structures. These soils can vary greatly in their characteristics and their response to external stimuli (ASTM Standard D, 2000, Bell & Walker 2000, Bera et al., 2007). When soils with unfavorable characteristics are encountered, they must either be discarded or treated in order to modify their properties to meet the requirements of the field. Cohesionless materials such as gravel, sand, and coarse silt are particularly susceptible to failure under low stress and have high permeability. In recent years, there has been increased interest in developing alternative materials and reusing industrial waste and by-products as a way to improve the strength and bearing properties of soils, while also reducing permeability. This can lead to cost savings in construction and reduced implementation time.

There are various techniques in geotechnical engineering that can be used to improve the mechanical and engineering properties of soil, but each technique has its own limitations and may not be suitable in all cases.

The geotechnical behavior of a material refers to its response to external loads, such as those applied during construction. This can include factors such as strength, stiffness, and deformability (Bell & Walker 2000; Bera et al., 2009; Clarlk, 1986; Gill et al., 2013). The geotechnical behavior of a mixture of sand, pond ash, and fibers under loading can be studied through laboratory testing, such as by applying various loads to the material and measuring its response. This can help

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to determine the potential suitability of the material for use in construction, such as in the creation of roads, embankments, or supporting structures. The subgrade soil can be modified to create an improved soil mix using mechanical or chemical methods (Nevels, 1993). This can involve adding one or more selected materials in various proportions, with or without a binder. The added material can be another type of soil or industrial by-products such as fly ash, bottom ash, or pond ash (Bera et al., 2009). Mechanical amendment involves adjusting the particle size distribution of the soil to increase stability, while chemical amendment involves the use of binders such as lime or Portland cement to improve the soil's properties (ASTM Standard D, 2000). Because the particles of pond ash are sub-rounded, there is less of an angle of friction between them and less opportunities for them to interlock with one another. As a consequence of this, when compared to the material that is commonly found in soil, the strength of pond ash is significantly lower. In earlier research and studies, the concept of increasing the carrying capacity of pond ash by reinforcing it with a variety of geo-grids, geo-synthetics, and fibres was investigated (Fatani et al., 1991, Chandra et al., 2008; McDaniel & Decker, 1979; Decker & Dunnigan, 1977) This was done with the goal of boosting the pond's ability to hold sediment. This was done with the intention of increasing the longevity of the pond ash (Chand & Subbarao, 2007). But in today's world, where there is a shortage of sand for use in various building projects as an infill material, pond ash may be used as an alternative to sand, and its bearing capacity can be increased by adding a layer of sand on top of it. This is because pond ash has the ability to hold more weight than sand does on its own. This is due to the fact that pond ash is capable of supporting far greater weight than sand can. In addition, before correctly compacted pond ash can be used in a number of sectors, it is necessary to have a thorough understanding of the characteristics of its strength as well as the other geotechnical properties it possesses. This is the situation due to the fact that pond ash may be discovered in many different habitats. The effectiveness of these techniques in improving the properties of in-situ soil can vary depending on the method used. Further research may be necessary to fully understand the geotechnical behavior of this material under different conditions and in different applications. Pond ash is created when coal is burned and the ash it produces is collected in a pond. Depending on the processing techniques used, pond ash can be divided into four different categories. In India, there are over 100,000 acres of land covered with pond ash lakes, and global production of pond ash is growing every year. However, proper measures should be taken to protect people, wildlife, and the environment when disposing of or using pond ash. Soil shear strength is an important factor to consider in geotechnical activities, as it affects the bearing capacity, stability, and design of structures (Bera et al., 2009) By mixing pond ash with other materials, such as sand and fibers, it may be possible to improve the shear strength of the soil and make it more suitable for use in construction. This study was designed to investigate the effects of mixing pond ash with other materials and subjecting it to loading. The results of this study could provide insight into the potential use of pond ash as a construction material in areas where good quality soil is not available.

Some of the approaches that are now utilised for the disposal of ash might have unforeseen repercussions on the ecosystem that is located in the surrounding area. These can include the reallocation of land resources, the contamination of water resources, the pollution of the air, and the negative effects on human health that can result from exposure to toxic air pollution. In particular: The creation of vast ash disposal regions results in problems with resettlement, as well as the loss of agricultural output, grazing land, and habitat, in addition to other land use consequences that come as a result of the redirection of large sections of land to trash disposal. These problems include the loss of agricultural output, grazing land, and habitat. In most cases, the design of the ash disposal zones themselves is inefficient, particularly with regard to making the most of the available land areas. Ash pond engineering practises aren't standardised in any manner in India (Emerson, 1964; Fell et al., 1992), which is one of the world's most populous countries. By dyking off naturally existing lowlands, certain facilities are generating ash storage areas in the form of shallow ponds in which to place the waste (Frenkel, 1978; Forrest, 1980; Gayathri & Kaniraj, 2012). This practise leads to an inefficient use of land areas for the buildup of a significant volume of garbage, which in turn results in environmental harm.

It is conceivable for the disposal of ash to cause damage to water resources. One example of this would be the contamination of groundwater caused by leach ate, as well as the contamination of surface water caused by the discharge of effluent from ash ponds. Both of these scenarios are plausible. The effluent that is created by ash ponds may either be used for drinking or as agricultural water, thus residents of the area have a choice between the two. Because local water sources are limited and distribution networks are almost nonexistent, leakage in ash slurry pipelines is exploited for irrigation and potable supply. Because of this, water from leaks may be used for both irrigation and as a source of drinkable water. When ash deposits are allowed to dry up in the absence of any water or vegetation cover, there is a chance that fugitive dust will be released into the atmosphere and contaminate it. The vast majority of the land area that is comprised of large ash ponds or ash dikes is not wetted or covered by water in the majority of instances. In time, the ash will lose its moisture and turn into a significant contributor to fugitive dust emissions (Gupta, 2021; Gray, 1986; Haliburton et al., 1975). The reclamation of arid places has, in certain instances, resulted in a decrease in the amount of fugitive dust that is released into the atmosphere. In the majority of cases, the areas where the ash ponds are located, the concentrations of repairable particles in the surrounding air are already rather high (Fell et al., 1992; Forbes et al., 1980).

2. REVIEW OF LITERATURE

One of the key differences between sand, pond ash, and fibers is their composition and microstructure. Sand is a natural granular material composed of small particles of rock and mineral, while pond ash is a byproduct of coal combustion, and fibers are typically man-made materials with a long, slender shape (Gray, 1986).

When it comes to their geotechnical behavior, sand is generally considered to have good strength and stiffness but can be susceptible to liquefaction under certain conditions. One important factor in improving the properties of soil is ensuring that the soil is well graded and has good composite characteristics. Well-graded soils have better contact efficiency, meaning they grip the soil more effectively. Some moisture can help with mixing fibers into the soil, but it does not affect the soil's strength. However, after a certain percentage of fiber content, there may be mixing problems and the fibers may clump together. Pond ash has been used as filling materials since good times. That’s reason several research studies might have been conducted on their uses as directly or indirectly with combination of other engineering materials. Pond ash, on the other hand, is often weaker and less stiff than sand, but can have a higher resistance to liquefaction. Fibers, meanwhile, are typically added to other materials to improve their strength and stiffness, but their effectiveness can vary depending on the type and number of fibers used, as well as the properties of the base material.

In a comparison study, it would be important to consider not only the inherent properties of each material, but also how they behave when combined with other materials, such as soil or concrete. This could provide valuable insights into the potential applications of sand, pond ash, and fibers in geotechnical engineering, and help researchers and practitioners choose the most appropriate materials for a given project.

Sridharan et al. (2001), did analyses to the standard results of Proctor tests for various Indian ashes and found that It resemble cohesion less sands/ sandy soils. Further the moisture content does not affect appreciably the dry unit weight, and that these curves are moderately flatter as compared to when prepared for the natural soils.

In a review published in 2004, Pandian discussed the characterization of fly ashes for geotechnical applications. He emphasized compaction, strength, and permeability, in order to identify their potential uses in construction. Pandian reported that fly ashes have several characteristics that make them useful in road construction and land reclamation, such as their low specific gravity, good drainage, and ability to be easily compacted. He also noted that fly ashes are generally inert and do not change significantly in response to changes in water content. Pandian concluded that fly ashes have potential for use in the creation of roads, the refurbishment of low- lying areas, and the filling in the back of storage buildings (Kaniraj & Gayathri, 2004).

Yadav et al. (2018) studied to investigate effects of adding pond ash and polypropylene fibers to cement-stabilized clay soils (Jafari, 2012). The researchers used 19 different combinations of these materials, with varying percentages of pond ash (10%, 20%, and 30%) and polypropylene fibers (0.5% and 1%), and subjected them to a series of standard strength and stiffness tests. The results proved on adding pond ash and fibers will increase strength in stabilized clay, decreased stiffness and reduced rate of strength loss. Study also found that the fibers had similar effect with the power of mixture. Researchers concluded coal ash may be utilized in combination as a substitute for clay soil in cement-stabilized mixtures when reinforced with fibers.

Pulverized coal ash that had not been treated and did not include any amounts of cementing agents was effectively utilised as a material for structural fill, as stated by Leonards (2021). The ash was fundamentally variable; despite this, it was possible to compress it to a level that was satisfactory provided that the moisture content was maintained at a level that was below the optimal level derived from routine laboratory testing and provided that the proportion of particles that passed through the No. 200 sieve was below 60%.

Bera et al. (2009) carried out study and experiments to investigate how well pond ash can be utilised as foundation media. The results of their research were presented in a publication in the year 2020. Pond ash has been the subject according to the results of several model experiments carried out in the laboratory employing square, rectangle, and strip footings. These investigations have been carried out in a variety of different ways. The order of these investigations has been maintained throughout their whole. The ultimate carrying capacity of shallow foundations is investigated in this study, along with the impacts of dry density, the degree of saturation of pond ash, the size a determine the shape of the footing, in addition to the other characteristics. The purpose of the study was to analyse the connections that exist between various components of the system (Wasti & Butun, 1996).

Even when the lime level is as low as 1.12%, documentation reveals the favourable effects that lime stabilisation has on the tensile and abrasion resistance qualities of class F pond ash. These benefits are seen even after the ash has been stabilised with lime at a higher concentration (Singh, 2007).

Researchers Kumar et al. (2008) conducted research on the behaviour of pond ash that had been reinforced with fibres that were randomly scattered throughout the material (Saran, 2010). They were curious to see what kind of response the content would have. Fattah et al conducted studies on the geotechnical characteristics of pond ash as part of their research (Das & Yudbhir, 2005). For the aim of their research, they took samples from both the outflow and the inflow areas of two different ash pond regions in India. All of these places may be found in India. In order to determine the consolidated material's overall level of strength, a series of triaxial tests accompanied by measurements of pore water pressure were conducted. In order to accomplish this goal, triaxial tests using consolidated drained (CD) and consolidated undrained (CU) specimens were carried out. Before being exposed to the many various forms of outside restricting pressures, the specimens of pond ash that were used in these studies were either fully loose or completely compacted. Both states were used in the research. The behaviour of the ash samples that were gathered near to the inflow point of the pond ash region was very similar to that of sandy soils in many different respects. This was discovered when the samples were compared to one other. These samples were taken from the region surrounding the pond ash that was burned. Their specific gravity and MDDs are both significantly lower than those of sands, but their strength was far higher than that of the reference material, which was the sand that could be found along the banks of the Yamuna river.

Kumar et al. disclosed the findings of a number of laboratory investigations (Choudhary et al., 2010) that were carried out on specimens of pond ash and silty sand that included random placements of polyester fibres. These research were carried out over the course of several years. The research was conducted on samples obtained from ponds, which were then put through their paces (Michalowski & Zhao, 1996). According to the findings, when fibre was added to soils with the intention of reinforcing them, the consequence was an increase in the maximum angle of friction, maximum compressive strength, maximum CBR value, and maximum ductility of the specimens (Fatani et al., 1991). When the specimens were put through their tests, this was likewise the situation. This was the situation in spite of the fact that the addition of fibre was done with the intention of fortifying the soils in some way. In addition, it was found that the ideal range for employing pond ash and silty sand for their respective uses is a fibre content that is around 0.3% to 0.4% of the dry density. This range was proven to be the optimal range. This range corresponds to the optimal range for using a fibre content of approximately 0.3% to 0.4% of the dry density. When it comes to the amount of fibre, these numbers indicate the "goldilocks zone.

In a study published in 2020, Gupta investigated the potential for using commercial byproducts, for stabilization in clayey soil when used for roads. The study found that these waste materials can add to increase stiffness and potency properties in soil when added in combination with the clay. Advanced testing methods were used to evaluate functioning in waste materials, including standard and four-day water immersion. The study concluded that the waste materials are non-toxic and harmless and can be used safely in pavement construction. Further research is needed to evaluate their performance on different types of soil (Gosh, 2020).

3. MATERIAL USED

A comparison study of the geotechnical behavior of sand, pond ash, and fibers under loading would likely involve conducting large number of tests for evaluation of the strength, deformation, and other characteristics of each material when subjected to various types of loading. This could include tests such as unconfined compression, triaxial shear, and direct shear, among others. The various materials used in the study are described as below:

3.1 Pond ash

This was collected in ash pool from thermal plant Ropar. The material was filtered through a 2mm filter to separate the foreign matter from the plants. The collected samples are thoroughly mixed to obtain homogeneity with the dried oven at a temperature of 105-1100C.

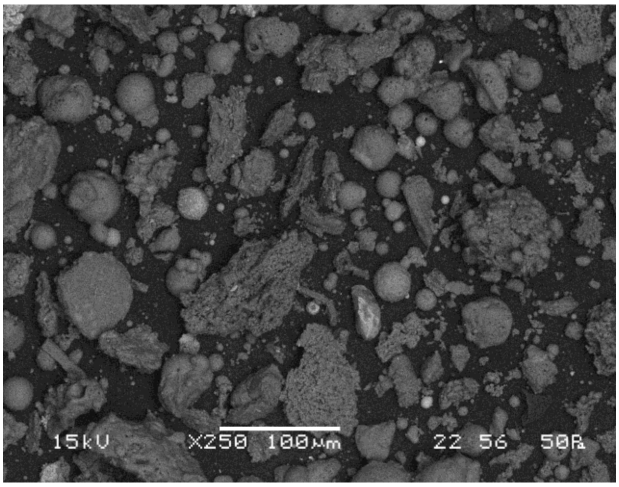

Figure 1. SEM image of pond ash

Samples of lake ashes are preserved in an air sealed storage structure so that's might be used in future without any apprehension. Fig 1 shows The findings of the analysis of the chemical components of the sample of pond ash that was small enough to fit through a screen with a measurement of 2 millimetres

3.2 Sand

Sand was collected from a nearby river. The sand was filtered through a 4.75 mm filter and the sample stones were removed and stored in a dry oven at a temperature of 105-1100C degree. The sand was stored in an airtight container to be used next and protected from water. It was then filtered through a sieve 2 mm and 0.425 mm. Sand transferred 2 mm and stored in in an air sealed storage structure so that's might be used in future without any apprehension. Table 1 given below gives geotechnical properties of pond ash procured from Ropar thermal plant.

Table 1. Geotechnical properties of material.

Parameter	Ropar
Silt size, 0.075-0.002 mm, %	22
Uniformity coefficient, *Cu*	4.78
Fine sand size, 0.475-0.075 mm, %	72

3.3 Geopolymer sheet

Geopolymers are new fire-retardant materials that are therapeutic applications, very hot pottery, new combinations of combustible, toxic fiber and radioactive waste encapsulation. The properties and uses of geopolymers exist has been tested in many fields of science and industry. Single layer reinforcement is applied to present study between a tank of ash samples of lake and sand to study the result reinforcement in carrying capacity.

3.4 Fibers

In the proposed study, commercially available polypropylene fibers of lengths 6mm and 12mm will be used. The physical properties of these fibers, as supplied by the manufacturer, are as follows: [Table 2].

Table 2. Physical Properties of Fibres.

Property	Values	Property	Values
Colour	White	Specific Gravity	0.91
Cut length	6mm,12mm	Equivalent diameter (µm)	32-55
Denier (d)	1.5	Water absorption (%)	85.22
Tensile Strength (MPa)	600	Acid resistance	Excellent
Melting Point (°C)	>250	Alkali resistance	Good

Fig. 2 depicts by using RECRON 3s, it is possible to prevent the shrinkage cracks that can happen when the material is curing. This leads in the structure/plaster/component having an inherent strength advantage. In addition, when stresses are applied to concrete that bring it closer to the point at which it may crack, the cracks that already exist in the concrete may propagate, sometimes very fast. The addition of RECRON 3s to concrete and plaster makes it easier to prevent cracking caused by changes in volume (expansion and contraction) and helps to halt cracking that has already occurred.

Figure 2. Perspectives on the fibres (Recron-3s)

These fibers will be mixed with sand and pond ash to create a composite material, and the geotechnical behavior of this material will be studied under various loading conditions. The aim of this research is to investigate the potential use of this material in construction, and to determine its suitability for applications such as road building and land reclamation (Pandey, 2004).

4. TESTS CONDUCTED

The following tests were conducted to the various combinations.

4.1 Specific Gravity

In accordance with the international standard IS: 2720 (Part-III, section-1), which was utilised throughout the course of the investigation, a calculation was made to establish the pond ash's specific gravity. After being put through a series of tests, it was discovered that the ponds' ash had a specific gravity of 2.37.

4.2 Grain Size Distribution

A sieve for the experiment had a 75-micron opening size, and the ash from the pond was passed through it microns so that a precise image of the grain size distribution could be obtained. In accordance with Indian Standard 2720 part (IV), 1975, the coarser particles were analysed using a sieve, and the finer particles were analysed using a hydrometer. Both of these methods were performed in accordance with Indian Standard 2720 part (IV), 1975. (IV). It was determined that using a sieve with a mesh size of 75 microns allowed for 33.7% of the pond ash to slip through it without being captured. As an immediate consequence of this fact, the particle size of pond ash can fall anywhere on the spectrum between the particle sizes of fine sand and silt. Both the coefficient of uniformity (Cu) and the coefficient of curvature (Cc) were found to be 1.25 for pond ash, with Cu equaling 2.15 and Cc equaling 1.25 respectively. This leads one to believe that the samples possessed a consistent gradation over the whole range.

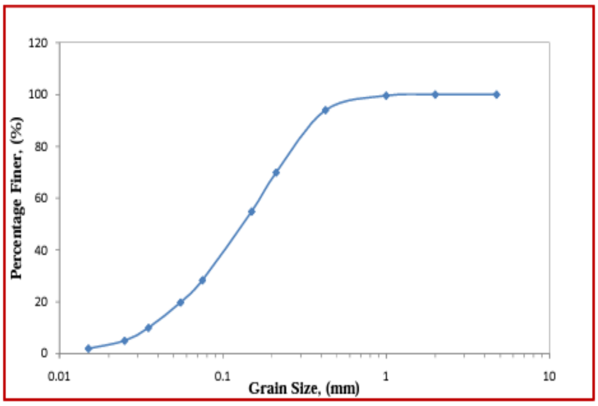

Figure 3. particle size distribution seen in pond ash

4.3 Compaction Characteristics

In order to determine whether or not there was a connection between the material's dry density and the amount of moisture it contained, compaction tests that adhered to IS: 2720 (Part 7) 1980 were carried out. These tests were carried out in order to determine whether or not there was a link between the two. These measurements were made so that we might have a better sense of the density of the material after it was dry, and they were taken in order to achieve this goal. To achieve the goals of The outcomes of this test were compared to those of an earlier test that had been conducted with a proctor rammer that was the industry standard and weighed 4.5 kg. The outcomes of these tests will be analysed to find out whether or not the pond ash may be utilised as a structural component in construction projects (DiGioia & Nuzzo, 1972). The results of this examination will be compared to the findings of a previous examination that was carried out using a standard proctor rammer that weighed 2.6 kilogrammes. The earlier examination was carried out in the past. It was determined, in accordance with International Standard 2720 (Part 2) 1973, how much moisture was contained in the compacted mixture. This was done so in order to comply with the requirements of the standard. This evaluation was carried out in order to demonstrate that we can fulfil the prerequisites outlined in the standard. The relationship that exists between the dry density and the moisture content was taken into account during the process of establishing both the optimal moisture content (OMC) and the maximum dry density. The OMC was determined by taking the maximum dry density and dividing it by the optimal moisture content. This was done in order to ensure that accurate results were obtained (MDD).

Experiments of a similar kind involving compaction were carried out with a number of different compactive energies, and the OMC and MDD values that correspond to each compactive energy were figured out. This was done with the purpose of identifying the influence that compactive energy has on OMC and MDD, and this was successfully accomplished. During this particular technique for conducting tests, the compactive energies that were utilised were as follows: The volume that was being compressed had kJ/m3 values of 357, 595, 1493, 2674, 2790, and 3488 respectively. Multiplying the volume that was being compressed by 3.48 led to the discovery of these figures. The findings of the tests are presented in a condensed but detailed format in Table 3.

Table 3. Test Findings.

Sl. No.	E (kJ/m3)	OMC (%)	MDD (kN/m3)
1	357	38.82	10.90
2	595	35.92	11.08
3	1493	31.38	11.60
4	2674	28.30	12.40
5	2790	28.72	12.61
6	3488	28.09	12.70

4.4 Shear Strength Characteristics

Out of all of these tests only permeability aspect has been discussed in this paper keeping length of paper and data in mind.

5. RESULTS AND DISCUSSION

The various geotechnical properties have been summarized in Table 1. Because the gravitational forces of a specific G of the lake ash are smaller than normal soil and the particles have holes in them naturally, the lake ash has lower MDD and OMC higher than normal soil. However, due to not much change in values practically, its possible to use them in combination with soils/sands along with other additives to improve the properties. Accordingly different combinations of sand, pond ash along with fibers encapsulated into the geo fiber sheet were subjected to different overburden pressures and were tested for varied permeability conditions.

5.1 Qualities of Compaction

The impacts of varying degrees of compaction on the properties of pond ash's compaction have been researched utilising a wide range of varied levels of compaction energy. Researchers have been able to explore these consequences as a result of this. These different degrees of compaction energy include 357, 595, 1493, 2674, 2790, and 3488 kJ/m3 of the volume that has been compacted respectively. There are also other numbers for the compaction energy, which come in at 2790 and 3488 kJ/m3, respectively. All of the information that was gleaned from the findings of this investigation up until this point has been analysed. In order to evaluate how the OMC and MDD values of pond ash samples relate to the compactive efforts that have been undertaken, an analysis was done on the pond ash samples. The findings of this study are compiled in Table 3.4. The relationship that exists between the dry density of pond ash and the quantity of moisture that it contains is depicted in Figure 4 over a wide range of various compaction energies. This figure shows how the relationship works. This connection may be seen to exist between these two things.

It has been demonstrated that an increase in the compactive energy results in an increase in the MDD, but at the same time, there is a reduction in the quantity of water that is required to achieve this density. This reduction in the quantity of water that is required to achieve this density has been shown to be the case. Figure 5 provides a graphical representation of the relationship that exists between stresses and compactive energy. The narrative indicates that the OMC first decreases rapidly as a result of compactive effort; but, after some time has passed, the rate of reduction is not as clear as it was at the beginning of the narrative. It has come to light that the MDD value has been steadily increasing at the same pace as the compactive energy has been developing. This correlation was made after it was found (Fig 6).

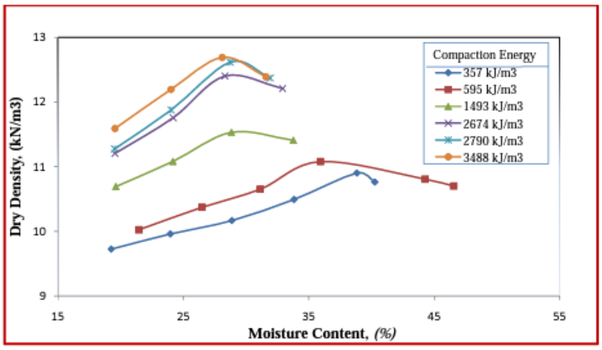

Figure 4. Dry density moisture at different compaction energies

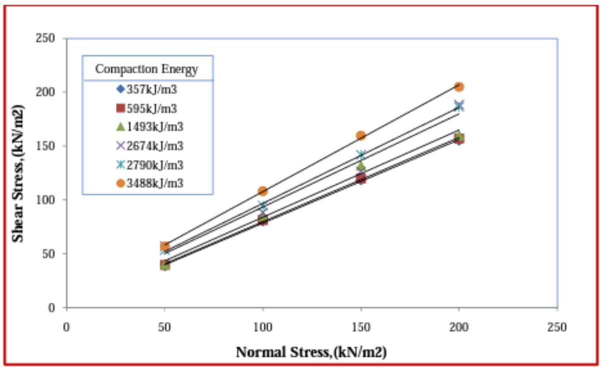

Figure 5. Stress variation under different compaction energies in shear as well as normal conditions

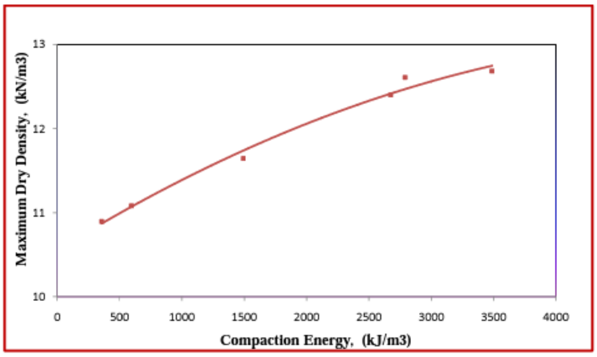

Figure 6. Changes in MDD under different compaction energies

The MDD of the specimens was found to increase from 10.90 to 12.70 kN/m3 when the compaction energy was adjusted from 357 to 3488 kJ/m3, while the OMC was found to drop from 38.82 to 28.09%. This was discovered when the compaction energy was increased from 357 to 3488 kJ/m3. This demonstrates that the density of pond ash after it has been compacted has a very poor response to the energy that is spent during the process of compacting it. This is the case because the energy that is spent on compacting it is relatively low. It's possible that this is the case for a number of reasons, but one of them is that the particles have a rounded form, and the sample has a constant gradation throughout shear Parameters.

Pond ash has been the subject of much research for its potential use in soil stabilization due to its ability to facilitate pozzolanic reactions and be used in large quantities. Residual lateritic soils (Setty & Rao, 1987), which have characteristic properties, can be difficult to work with and compact in the field and may have low strength. Fly ash stabilization may help to overcome these difficulties and improve the properties of these soils (Indraratna et al., 1991).

Pond ash is a by-product of coal-fired power plants and is often used in geotechnical engineering applications, including soil stabilization. The strength of pond ash can be evaluated using a triaxial shear test, which measures the soil's resistance to shear stress. This test is commonly used to determine the soil's shear strength parameters, such as the cohesion and internal friction angle, which can be used to predict the soil's behavior under various loading conditions. The results of a triaxial shear test can provide important information about the strength and deformation characteristics of pond ash and how it may behave in a given application.

6. CONCLUSIONS

The gradation of the particles in the pond's ash is consistent all the way through, and the grains range in size from extremely fine sand to silt. The pond's ash is formed of the silt. When compared to the specific gravities of the various types of earth minerals, the specific gravity of particles has been shown to be significantly lower than that of traditional earth. Compaction energy increases particle packing, increasing dry density and decreasing optimal moisture content. The material's density after drying out is increased as a direct result of this factor. It has been demonstrated that the dry unit weight of compacted specimens may vary anywhere from 10.90 to 12.70 kN/m3 when the compaction energy is raised from 357 to 3488 kJ/m3, while at the same time, it is possible to see that the total material content may fall from 38.82% to 28.09%. This illustrates that the sample of pond ash has a very poor reaction to the energy that is utilised during the process of compaction.

There is a one-to-one relationship between an increase in the compaction energy and a proportional increase in the angle of internal friction as well as the unit cohesion. Both of these properties rise in tandem with the increase in the compaction energy. This is due to the fact that the material has a larger density than it did in the past. It has been shown that there is a correlation between these parameters; however, this connection does not follow a linear pattern.

The permeability of pond ash can be evaluated using a variety of laboratory tests, such as the constant head or falling head permeability test. These tests measure the soil's ability to transmit water through its pores or voids. The results of a permeability test can provide important information about the soil's ability to transmit fluids, which can be useful in determining its suitability for various engineering applications.

According to laboratory research on the combination of lake ash, sand, and fibers, the coefficient of permeability at zero normal stress is higher for all the tests than it is at higher values of overburden pressure. This indicates that increasing overburden pressure can reduce the value of the coefficient of permeability. The suction capacity of the fibers in the lake ash and sand combination is also found to be higher than that of lake ash and sand used separately.

The value of unit cohesiveness rises as the degree of saturation approaches the OMC, but after reaching that threshold, it begins to fall once more and continues to do so until it reaches its minimum. When samples are compacted at conventional densities as well as modified densities, the point of maximum cohesion (OMC) produces the highest value of unit cohesion. This is because OMC creates the maximum value of unit cohesion. On the other hand, as the degree of saturation increases, the value of the angle of internal friction decreases in a way that is linearly proportional to the increase in saturation. When there is a greater degree of friction between the two surfaces, the effect is exactly the reverse of what you would expect. The first measurements experience a precipitous drop, which is followed by a period of gradual recovery to levels of moisture that are greater than OMC.

It was discovered that increasing the amount of fibre that was present in the reinforced specimens led to an increase in the undrained cohesiveness of the unit. This was the conclusion reached by the researchers. The rate of expansion of unit undrained cohesion, on the other hand, does not rise in a linear fashion with the concentration of fibre present in the material. Beyond an early period of rapid expansion, the pace of rise begins to slow down, and the subsequent increase in unit cohesiveness becomes less noticeable after that point (Ranjan et al., 1999).

If you keep the compacted density and the fibre content the same, the data show that using fibres with a size of 12 millimetres provides a material with more strength than using fibres with a size of 6 millimetres. This is the case regardless of whether or not the amount of fibre is maintained at the same level. This is still the case even when comparing meals that have the same amount of fibre. Fibers have the capacity to alter the stress situation in the specimens and relocate the shear along the failure plane to the mass that is immediately surrounding the failure site. This may be done by changing the orientation of the fibres. This is made possible by the combined activities of adhesion and friction that take place between the fibre and the ash particles (Santoni, 2001). The fibre and the ash particles work together to achieve this result. Because the fibres interact with the ash particles, it is possible for this to take place. The reason for this is given in the previous sentence (Setty & Rao, 1987).

After reaching a sustained degree of saturation between 13% and 14%, the unconfined compressive strength begins to grow. This trend continues until the material is completely saturated. On the other hand, along with this rise comes a decrease in both the standard and modified proctor density. This occurs as a result of the fact that the additional water has a lubricating effect on the surface of the ash particles, which in turn makes it simpler for the ash particles to be moved around. When compared to the optimal moisture level, a lower percentage of water content leads to an increase in the unconfined compressive strength of the material. This effect can be attributed to the fact that less water is being contained inside the material. This impact may be ascribed to the fact that the material absorbs less water over time, which causes it to hold less water overall.

The failure stresses and initial stiffness values generated by the samples that were compacted with higher compaction energy were significantly higher in comparison to those that were produced by the samples that were compacted with lower compaction energies. This is the case regardless of the kind of sample that is being used in the investigation. On the other hand, it was found that failure stresses are lower in samples that were crushed with a greater amount of energy. This was an interesting finding. Failure stresses in the specimens were discovered to have values that varied from 0.75 to

1.75 percent, which is indicative of brittle failures happening in the material. The failure stresses were observed in the specimens. It was discovered that there is a relationship that may be described as linear between the amount of compaction energy and the unconfined compressive strength of the material. Researchers have discovered that these two things are connected. The findings of the inquiry provided the evidence that the researchers needed to support their conclusion. Remember to keep this in mind because it turned out to be an interesting discovery.

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