

Influence of pond ash on the behaviour of soil: A Review

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Abstract: Due to rapid industrialization energy generation is increasing day by day. This energy generation by numerous power plants cause production of industrial waste. Generation of these wastes is a big threat to our society and environment. So we either have to find ways to dump these wastes safely or to use these wastes in a constructive manner. Industrial wastes have been gaining importance as a geotechnical material in the present days. Due to specific advantages, materials like flyash, pond ash have been considered as a replacement to natural soils. Different research is done on the behaviour of soil mixed with these industrial wastes to understand the potential of these waste in the improvement of engineering behaviour of soil. It is found from the studies that these industrial wastes can be used as admixture for the improvement of weak or poor soil. Pond ash is a waste material and it is mainly obtained from the wet disposal of the fly ash, which when get mixed with bottom ash, disposed off in large pond or dykes as slurry. In this paper the review of different studies, where pond ash is used as admixture for the improvement of engineering properties of soil is presented.

Key words: Pond ash, engineering properties, fly ash

INTRODUCTION

In developing countries like India thermal power is the main source of energy and produces nearly 75 per cent for total energy production. The coal ash generated from all the existing thermal power plants is over 100 million tonnes per year. This coal ash is obtained in the form of fly ash (70%) and pond ash (30%). It is important to utilize these waste materials for take care of environment. The fly ash along with pond ash or bottom ash generated by the industries is generally disposed of in an engineered ash pond in a form of slurry in a ratio varying from 1 part ash and 6 to 10 parts of water which are situated within few kilometres distance from the power plant. This is why it is called pond ash. In fact, the pond ash is a mixture of fly ash and bottom ash. The main difference between pond ash and fly ash is in their particle size. The pond ash is coarse and less pozzolonic and hence is not being accepted as pozzolona (Sonawane and Dwivedi 2013). It is also the social responsibility of researchers to find the ways to efficiently use the industrial by-products

in order to preserve our precious resources, conserve energy and reduce or eliminate the need for disposal of industrial waste in landfills. This Paper highlights the potential of Pond ash in the geotechnical field.

POND ASH

Since, pond ash is the residue after combustion of coal in thermal power plants, so its properties depends upon the coal used and may vary from one power plant to other power plant. Particle sizes of the ash vary from around one micron to around 600 microns. The very fine particles (fly ash) collected from this ash generated by electrostatic precipitators are being used in the manufacture of blended cements. Unused fly ash and bottom ash (residue collected at the bottom of furnace) are mixed in slurry form and deposited in ponds which are known as pond ash (Bhangale and Nemade 2013). About 120 million tons of pond ash is produced in India (Havanagi et al. 2011). This huge amount of industrial waste can cause serious hazards to the world. The fly ash and pond ash are one of the responsible pollutants of air, soil and water. These wastes require huge space for their disposal. Therefore it is necessary to increase the constructive use of these wastes in construction industry (Patil and Patil 2013). About 25% is utilized for Roads, Buildings and other Civil engineering applications. Bulk utilization of Pond ash is being carried out for road embankment construction in the ongoing massive road development programs taken up by the Government of India viz. National Highway Development Program (NHDP) and Pradhan Mantri Gram Sadak Yojana (PMGSY) (Havanagi et al. 2011).

Many studies are done to evaluate the effect of the pond ash on the behaviour of soil. All researchers have reported that soil mixed with pond ash can be used in different applications like for construction of embankment, under foundation or as fill material etc. (Satyanarayana et al. 2013, Sonawane and Dwivedi 2013, Marrapu and Jakka 2012, Ghosh et al. 2004, Patel et al. 2013). Pond ash has potential to improve the engineering

behaviour of soil. Physical and chemical properties reported in different studies are presented in Table 1 and Table 2 respectively. It can be observed from the Table 1 that specific gravity of pond ash is less as compared to the specific gravity of soil particles. It can be further seen in Table 2 that silica content in Pond ash is very high. Such high content of silica is reason for the pozzolonic activity up to some extent. Fig. 1 shows the SEM picture of the Pond ash and the shape of particle is found out to be Spherical.

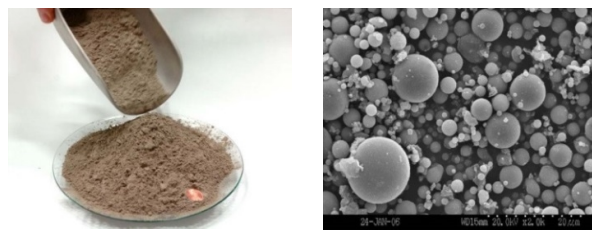


Fig.1 The original picture and SEM picture of Pond Ash (University of Kentucky Centre for Applied Energy Research)

Table 1 Physical property of Pond Ash (Ghosh et al.

Property	Range of Values
Grain Size Distribution	
Gravel (%)	0
Sand (%)	72-95
Fines (%)	
(a) Silt (%)	5-30
(b) Clay (%)	0-25
Consistency	
Liquid limit (%)	Non Plastic
Plastic limit (%)	Non Plastic
IS Classification	SP-SM
Specific Gravity	2.0-2.4
Compaction Characteristics	
Optimum moisture content (OMC) (%)	14-37
Maximum dry density (MDD) (g/cc)	1.3-1.4
Angle of shearing resistance(deg)	28-36
California bearing ratio (%)	1.3-12.2
Coefficient of permeability (cm/s)	2×10^{-6} to 3.6×10^{-5}

2004, Patilet et al.2013, Sarkar et al.2012, Satyanarayana et al.2013)

Table2 Chemical Property of Pond Ash (Ghosh et al. 2004, Sarkaret al. 2012, Sonawane and Dwivedi 2013, Kumar and Rajasekhar 2009)

Constituent	Value (%)
Silica (SiO ₂)	50.5 – 67.4
Alumina (Al ₂ O ₃)	1.38 – 25
Iron Oxide (Fe ₂ O ₃)	0.71 – 9.81
Calcium Oxide (CaO)	2.7 - 9.73

Magnesium Oxide (MgO)	0.45 – 4.18
Sulphur (SO ₃)	0.06 – 0.3
Loss on Ignition(LOI)	8.22 – 10.53

EFFECT OF POND ASH ON THE SOIL PROPERTIES

Many researchers have conducted different type of experiments to find out the properties of soil mixed with Pond ash. Table 3 shows the Geotechnical behaviour of Pond ash. The effect of mixing of Pond ash on the engineering Properties and Index properties of soil is explained in the sections presented below.

Plasticity behaviour soil

Plasticity of soil depends upon the minerals and the properties of the soil. Pond ash itself is non plastic material (Table 1). By mixing of Pond Ash in the soil, plasticity behaviour of soil changes with amount of Pond Ash and it also changes the values of Atterberg limit (Bera et al. 2010). Due to mixing of the pond ash plasticity index decreases (Bera et al. 2010, Nicholson and Kashyap 1993). Also from the similar type of behaviour is found for liquid. With increase in the pond ash the liquid limit decreases (Bera et al. 2010, Bairwaet al.2013). Pond ash has non plastic particles, due to which when it is added in the soil plasticity behaviour of soil decreases. Similarly because of change in the amount of plastic particles in the mix of soil and pond ash liquid limit decreases.

Compaction behaviour of soil

Compaction behaviour of soil depends upon the type of soil. The maximum dry density (MDD) and optimum moisture content (OMC) are the benchmark for determination of quality compaction for any earth work project. For coarse grained soil maximum dry density is greater than fine grained soil. While optimum moisture content (OMC) of coarse grained soil is less than OMC of fine grained soil. A decrease in MDD and increase in OMC with addition of pond ash content has been obtained by experimentation for fine grained soil (Bera et al. 2010, Kolay et al. 2011).

Table 3 compaction properties

Constituent	Value (%)
Silica (SiO ₂)	50.5 – 67.4
Alumina (Al ₂ O ₃)	1.38 – 25
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Swelling behaviour of soil

Expansive soils or swelling soils are soils that expand when water is added, and shrink when they dry out. This continuous change in soil volume can cause homes built on this soil to move unevenly and crack. Non-expansive soil undergoes large compaction at high water content (Kumar and Sharma 2007). There are different techniques like replacement of expansive soil, modification of soil and use of foundation like belled piers, underreamed piles are generally adopted by Geotechnical engineers. Use of admixtures for the modification of the property of swelling soil is one of the ground improvement techniques. Pond ash has potential to suppress the swelling behaviour of soil (RajdipBiswas 2008, Patil et al. 2013, Mollamahmutoglu et al. 2009). Since pond ash is a non-plastic material, so when it is mixed with the swelling soil it suppresses the swelling tendency of soil.

Strength Parameters of soil

With the increase in the amount of cementitious material, the strength of soil increases. Pond ash has shown the cementitious properties. It has silica content, which shows the pozzolonic reaction. The pozzolonic reaction increases the cementitious quality in the soil. It has shown by study that with increase in the quantity of Pond ash, strength of soil increases (AlokSharan 2011). The California bearing ratio (CBR) of a soil is one of the important parameters in evaluating design criteria for use as a pavement construction material. CBR value also increases with increase in the Pond ash content (Bera, et al. 2010, AlokSharan 2011, Santos et al. 2011, Debet et al. 2014). It is found that with increase in pond ash content of fine-grained soil pond ash mixture, the values of UCS decrease. It may be due to that with increase in pond ash content, the fine-grained soil altered into more friable "less clayey" form as a result; therefore cohesive strength may decline (Bera et al. 2010)

CONCLUSIONS

This Review Paper Briefly discussed the effect of Pond ash on the behaviour of soil mixed with the Pond ash. For the sake of protecting the environment and the better utilization of the industrial waste material for geotechnical purposes it is important to understand its impact on the behaviour of soil. It is found out that the shape and size of the Pond ash, particle size distribution, Physical Properties, chemical constituents etc. are mainly affecting the geotechnical properties of Mix. Yet further Research is required to understand the mechanism and potential of Pond ash with different type of soil for the improvement of Behaviour and properties of soil.

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