International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2017): 7.296

Study on use of Thermal Power Plant Waste as Filling Material in Road Embankment

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Abstract: ***The social and economical development of a country depends on various social parameters as well as availability of various infrastructural facilities. Among the various infrastructural facilities available for development the road transport infrastructure plays an important role for an under developing country. Therefore, the soil is the prime need for filling for the construction of road, highway embankments. Natural river sand and local sand are used as the conventional filling material. Large amount of natural soil and aggregates are also required to excavated or to be deposited as filling material for roads, highway, embankment and mining is ban by Government and needs the approval. Now –a day's motivates of development of alternative methods to solve the environmental and economic issues by reusing industrial waste product, and also fulfill the specifications economically. Day by day electrical power requirement is increasing and also increasing thermal power plant waste which generate environmental problems for the people who live around it and statistical observation shows that the current rate of deposition of Pond ash in India has reached approx 170 million tons/annum. About 90,000 acres of precious cultivable land is used for the storage of abandoned ash. But the current rate of utilization of ash is only about 35-40%.The unused ash leads to an increasing ponding area for storing of ash and related environmental problems for the people who live around the power plants. Besides this, over the last few years, due to development the construction of highways and roads has taken a boost. This requires a large amount of natural soil and aggregates. These are some issues now-a-days which motivates in development of alternative methods to solve the environmental and economic issues. Limited work has been reported in the literature on evaluation of the geotechnical properties of pond ash and their utilization in filling in the road embankment. This present work aims to find out bearing capacity with added in virgin soil in different proportion and layers to find out the maximum bearing strength, to bring in environmental & economical benefits in an eco-friendly manner.***

Keywords: pond ash, filling material, waste material, power plant waste, Road, Embankment, Fly over

1. Introduction

Over the last few years, environmental and economic issues have large interest in the development of alternative materials and reuse of industrial waste or by-products. Thermal power plants release waste materials as by-products which are threat to public health, ecology and environment. It consumes a large area and also has many environmental hazards. A material such as pond ash is a residue collected from ash pond near thermal power plants. These micron-sized earth elements primarily consist of silica, alumina and iron. Due to increasing in industrialization and the scarcity of availability of natural soil it is necessary to utilize the waste products of power plants as a replacement to the natural soil. This will reduce the scarcity of natural soil and also solve the environmental issues due to the deposition of the by-products. However, due to lack of sufficient knowledge due to insufficient research, its use has not taken momentum. But till now the basic and essential parameters of pond ash, to be used in filling material in road embankment.

In an under developing country the development of transportation infrastructure is the key to overall development of a country. For countries like India, where resources are limited, the subgrade, which is the bottom most layer of the pavement, is made up of compacted soil . The road alignment is decided based on many factors of which one is the availability of good soil along the proposed alignment. But with scarcity of land for excavation, other resources as natural soil, sand etc. the road embankments may be used pond ash adding with natural soil as filling material over existing soil deposits which brings in environmental and economic benefits. Pond ash has good potential for use in construction as a suitable material. The strength of the pond ash is less as compared to the conventional earth material because of less angle of friction and interlocking between the particles as the shape of pond ash particles is sub rounded. As compared to the natural soil or sand, the weight of pond ash is very less and it has self-drainage capability and before its successful application in various fields it is necessary to know the strength characteristics and different geo-technical properties of suitably compacted pond ash.

Some waste materials such Fly Ash, rice husk ash, pond ash, PET, HDPE may use to make the soil to be stable. Addition of such materials will increase the physical as well as chemical properties of the soil. Some expecting properties to be improved are CBR value, shear strength, liquidity index, plasticity index, unconfined compressive strength and bearing capacity, permeability etc. The objective of this study was to evaluate the effect in stabilization of Soil (CL-ML) Using Pond Ash in different percentage. Increment of CBR value is used to reduce the thickness of the pavement, increase the bearing capacity of soil, reduce swelling behavior of soil etc.

Pond Ash: Unused Fly ash and Bottom ash are mixed together and transported in the form of slurry to stored in the ponds which is known as Lagoons (Fig.-1). In the pond area, when ash gets settled and excess water is removed then the deposit is called pond ash. Among the industries thermal power plants are the major contributor of pond ash. Besides, this steel, copper and aluminum plants also contribute a substantial amount of pond ash.

Figure 1: Storage Lagoons of Pond Ash

Sampling of Pond Ash: Pond ash is potentially useable, but is variable in its characteristics because of its manner of disposal. Because of differences in the unit weight of fly ash and bottom ash, the coarser bottom ash particles settle first and the finer fly ash remains in suspension longer. The ash deposited with in about 100 m of ash slurry discharge point in the pond is coarser ash as compared to the ash deposited away from 100m.

Figure 2: Sample of Pond Ash

Physical property of pond ash
The Physical Properties of pond ash is described in the following Table-1

Table 1: Physical Properties of Pond Ash

S. No	Properties	Pond Ash
1.	Lime Reactivity of Pond ash	0.66
2.	Specific Gravity	2.16
3.	Bulk density in Loose State	824 kg/m3
4.	Bulk density in Compacted State	990 kg/m3
5.	Atterberg's Limits Liquid Limits percentage	47.3
6.	Grain size distribution Sand % Silt % Clay %	 72 28 NIL
7	IS Classification	SP-SM

Chemical compositions of pond ash
The chemical composition of pond ash is described in the following Table-2

Table 2: Chemical Compositions of Pond ash

Constituent	Pond ash (%)
Silica (SiO2)	67.40
Alumina (Al2O3)	19.44
Iron Oxide (Fe2O3)	8.5
Calcium Oxide (CaO)	2.7
Magnesium Oxide (MgO)	0.45
Sulphur (SO3)	0.30
Loss of Ignition	2.50 - 3.46

2. Experimental Investigations

Various properties as Atterberg's limit (liquid and plastic limit) , CBR, OMC &MDD etc. tests have been performed to find out the engineering properties of virgin soil and by adding Pond Ash in proportion as 5%, 10%, 15%, 20 % and 25% respectively to find out the maximum bearing strength.

Material Used 1- About 150 kg of virgin soil (silty clay) sample collected from the Lambhua, Sultanpur,, Amethi, Utter Pradesh. 2- Pond ash sample was collected from the pond of NTPC, Ucchahar, Raebareli.

Laboratory test carried out on virgin soil sample
The specific gravity of pond ash and virgin soil is found 2.15 & 2.67 respectively. Other tests were carried out on the virgin soil sample & the details are given in the following table-3

Table 3: Properties of virgin Soil Sample

S. No.	Soil Properties	Value
1	Specific Gravity	2.67
2	Grain Size Analysis	
	Gravel	0.04%
	Sand Content	3.10%
	Silt	58.24%
	Clay	38.62%
3	Atterberg's limits	
	Liquid Limit	25.86
	Plastic Limit	19.71
	Plasticity Index	6.15
4	Soil Classification	CL-ML
5	Optimum Moisture Content	16.05%
6	Maximum dry density	1.72 g/cc
7	CBR	4.48

Standard Proctor Test
Proctor tests were conducted to find out the OMC & MDD of the virgin soil samples and also the soil samples mixed with various percentages of Pond Ash as given in Table-4 .

California Bearing Ratio
Saturated CBR tests were conducted on the virgin soil samples and also samples mixed with various percentages of Pond Ash as given in Table -4

Figure 3: Standard Proctor Test & CBR Apparatus

Table 4: Specific Gravity, OMC, MDD, Saturated CBR of virgin Soil and mixed with various percentage of Pond Ash

Virgin Soil	Pond Ash	Specific Gravity	OMC	MDD	Saturated CBR
100%	0%	2.67	16.05%	1.72	4.48
95%	5%	2.56	16.17%	1.73	4.82
90%	10%	2.53	20.12%	1.68	5.69
85%	15%	2.53	18.53%	1.67	6.03
80%	20%	2.43	16.28%	1.66	6.67
75%	25%	2.36	21.31%	1.64	5.89

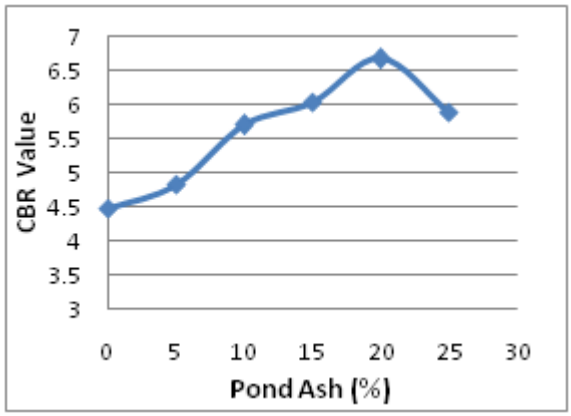

Figure 4: CBR value of soil added with different % of Pond Ash

Effect of virgin soil sample over laid by pond ash in the layers:

For the purpose of further improvement of the virgin soil and utilization of pond ash practically, the soil and pond ash are compacted in the form of layers of 25mm, 50mm and 75mm respectively to obtain maximum CBR value. The Saturated CBR value of different thickness of different layer of soil sample over laid by pond ash as given in Table -5

Table 5: CBR value of different thickness layer of soil sample over laid by pond ash

S.No.	Thickness of Layers of Pond Ash and Virgin Soil	CBR %
1	25MM	5.16
2	50MM	5.84
3	75MM	5.64

Figure 5: CVR Mold

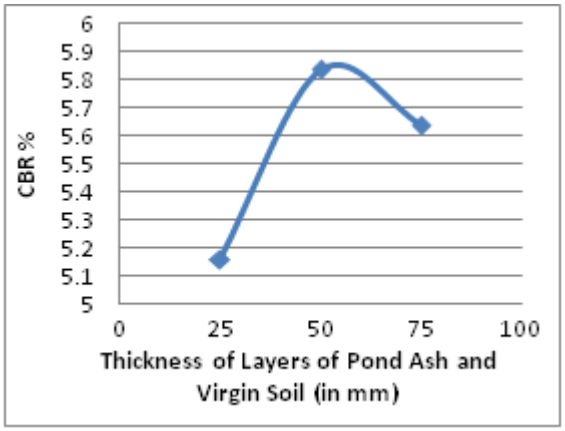

Figure 6: CBR vs Thickness of Layers of Pond Ash and Virgin Soil

3. Conclusions

Based on the experimental data collected the soils used for experiment found silty clay and classified as CL-ML mixed with Pond Ash in Five different proportions (0 %, 5%, 10%, 15%, 20% and 25%). Further the soil and pond ash are compacted in the form of layers of 25mm, 50mm and 75mm thick respectively and maximum saturated CBR value is found in the layer of 50mm thick . Pond Ash in the sequence of layers with soil, which is practically possible for utilization in the filling of Road Embankment. The main conclusions as given below:

1) For soils only: Soil used for experiment has specific gravity 2.67 and has been classified as (CL-ML) with LL, PL, PI, OMC and MDD as 25.86, 19.71, 6.15, 16.05%, 1.72 g/cc respectively. The saturated CBR value of virgin soil is found 4.48.
2) Soil mixed with Pond ash in different proportions :
   a) The specific gravity Pond Ash and Virgin Soil are 2.15 and 2.67 respectively. The specific gravity of Virgin Soil changes from 2.67 to 2.36 which shows a continuous decreasing trend with increase in addition of Pond ash from 0 to 25%. This may be attributed to increase in silt content as compared to reduction in clay content.
   b) The experimentally obtained saturated CBR values shows a continuous increasing trend with maximum

value as 6.67 at 20% addition of Pond ash which is about 48.88 % more compared to virgin soil.

3) Soil sample over laid by Pond Ash
   a) For the purpose of further improvement of the virgin soil and utilization of pond ash practically, the soil and pond ash are compacted in the form of layers of 25mm, 50mm and 75mm respectively to obtain maximum CBR value.

From the experimental results it is possible that the soil may be used with Pond Ash in the sequence of layers, which is more practical and economical for utilization of Pond Ash as compared to mixing with virgin soil. The soil and pond ash are compacted in the form of layers of 25mm, 50mm and 75mm thick respectively and the best result is found in the layer of 50mm thick with maximum saturated CBR value i.e. 5.84 which is about 30.36 % more compared to virgin soil.

Concluding Remarks: Pond Ash is Thermal power plants release waste material as by-product which is threat to public health, ecology and environment. Construction of highways and road embankments, abutments, earthen dams and other retaining structures in India which requires a huge amount of natural soil and aggregates to meet this demand, further huge amount of exploitation of fertile soil and natural aggregate is being adopted. By utilizing of Pond Ash may reduce the cost of structure, reduce the scarcity of natural soil and also solve the environmental issues.

4. Acknowledgment

I Devi Prasad Vishwakarma, Authors, thankfully acknowledges to Dr. U. K. Maheshwari, Professor & Head, Dr. N. K. Saxena, Professor & Supervisor, Prof. Anupam Verma , Asstt. Prof. & Supervisor, Civil Engineering Deptt. K.N.I.T., Sultanpur for invaluable guidance, suggestion, encouragement which helped me carrying out my thesis work successfully, I am also thankful to General Manager, Hindustan Aeronautics Limited , Amethi, for permission of M.Tech. from KNIT, Sultanpur, Mr. S.K. Chaudhury, DGM(Works), Mr. S.K. Chaturvedi SM(Works), Mr. S.K. Maurya, SM(Works), Civil Engineering Deptt. of Hindustan Aeronautics Limited for supporting me during my M.Tech.

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