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Experimental Investigation on Soil with Pond Ash and Alccofine

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ABSTRACT

Cohesive soil causes great engineering problems due to its poor strength, high compressibility and low permeability. It covers large and extensively located areas of India and also many parts of the world. Silty soil extends in large stretches and construction of pavements and other structures on such type of soils is a great problem. To set right these problems, it is very much necessary to treat these soils. There are so many methods for the treatment of these soils. Some of them are very costly and some are very tedious. Several-methods of soil-improvement using Pozzolanic materials have been developed and used successfully in practice. The treatment of soft clayey soils with flyash, Rice husk ash, Phasphogypsum along with small quantity of cement is very simple, economical and pollution controlling. It has been useful in a diversity of civil-engineering works, like in the construction of base-courses, where good materials are not economically available; for reducing the permeability and compressibility of soils in hydraulic and foundation works; for stabilization of slopes, embankments and excavations. A considerable amount of research concerning stabilization of soil with additives such as cement, alccofine, lime – fly ash and salt, bitumen and polymers is available in the literature. Likewise, the coal ash considered as an industrial waste can be effectively used in the construction industry.

1. Introduction

Soil can be defined as the upper layer of the earth consisting of air, water and solid particles is generally produced by disintegration of rocks. In the third world countries, the need for locally manufactured construction material is increasing due to greater demands for new roads and housing units created by a growing population. Over the years, the availability of conventional material has not been sufficient to meet the demand of growing population. However, development of a large network of roads by traditional means and techniques require heavy financial investments. So, it becomes need of the hour to find alternative materials, preferably locally available low grade ones for use in pavement construction, which results in sizeable economy without compromising with the engineering performance of structure. Abundantly available soilis the cheapest construction material in most of the regions of the world. The properties of the soil vary from point to point and place to place.

2. Pond Ash

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 tons 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 kilometers 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 pozzolanic and hence is not being accepted as pozzolana.

3. Alccofine

There are many byproducts which are generated from industries and factories, dumped openly which cause environmental problems and also spread diseases. These byproducts can be utilized in useful way to save the environment. These by-products or so called waste materials are fly ash, silica fume, ground granulated blast furnace slag and alccofine which are being reused now a days in construction industries for soil stabilization or concrete production mainly by making few stabilized changes in these waste materials.

Table 1.1: Chemical Composition of Alccofine 1203

CaO	Al2O3	SiO_2	Glass content
31-33%	23-25%	33-35%	>90%

4. Literature Gap

In India and other developing countries, 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 tons 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. 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. The potential-impacts, on the, environment suggested that there is a need for proper-disposal of pond-ash and justify maximum-utilization of pond-ash when it is almost viable. The commonly used material that is Alccofine is a granulated blast furnace slag based microfine material designed for soil stabilization. In-this-context, an extensive, research is needed, to understand, the- ,mechanism and, geo-engineering, properties, of expansive-soil, stabilized with -fly -ash in -combination -with Alccofine. However, the broad -overview of the -literature reveals, the following, gaps, in the study:

- The researchers have used various waste materials as soil stabilizers but the combination with Alccofine has still not been used by the researchers as soil stabilizer.
- The generation, of pond, ash is far-in-excess of its utilization and its combination with Alccofine could result in significant enhancement that has not been reported in literature.

Above gaps shows that there is a need to concerning the soil stabilization of pond ash and Alccofine treated soil and more investigations are desirable.

5. Objectives Of The Study

1. To stabilize the locally available weak subgrade, by using 3 per cent of alccofine and with varying the pond ash as the main stabilizing material.
2. To study the influences of pond ash content on the OMC and MDD, strength parameters, and the soaking effect.
3. To arrive at the optimum pond ash content.
4. To study the load settlement behavior of soil with different pond ash mixes.

6. Scope of the study

The scope of the work includes characterization of the soil and pond ash, determining the moisture-density relationship with respect to IS-light compaction for the soil blended with 3 per cent alccofine and with varying pond ash content and determine the laboratory CBR and Modulus of Subgrade reaction values for the same mixes. The main purpose of adding pond ash to soil is to alter the gradation and make the soil coarser and alccofine is for binding action.

7. Description of the mixes

Table 1.2: Description of mixes

Sr. No.	Mix nomenclature	%age of locally available weak soil	%age of pond ash as stabilizing agent	%age of alccofine as enhancing agent
1	M1	85	15	0
2	M2	80	20	0
3	M3	70	30	0
4	M4	50	50	0
5	M5	82	15	3
6	M6	77	20	3
7	M7	67	30	3
8	M8	47	50	3

8. Result and Discussions

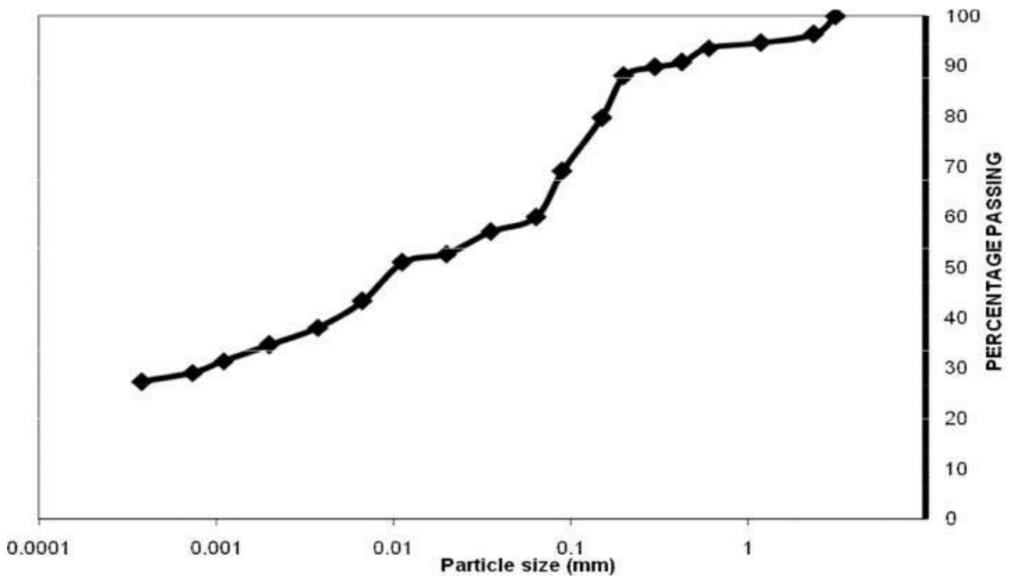

Fig - 1.1: particle size distribution curve of the natural soil

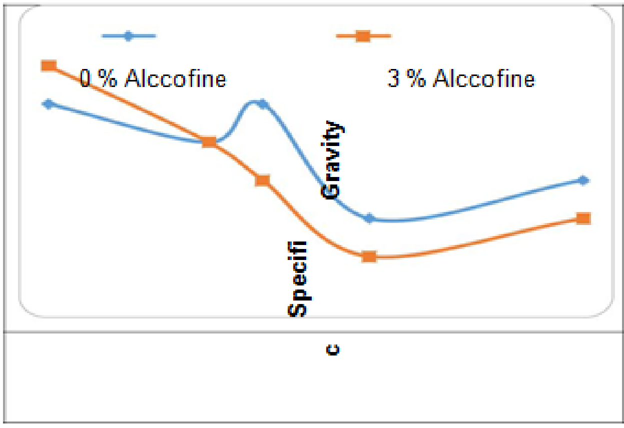

Fig -1.2. Specific gravity for soil/soil-pond ash–alccofine mixes

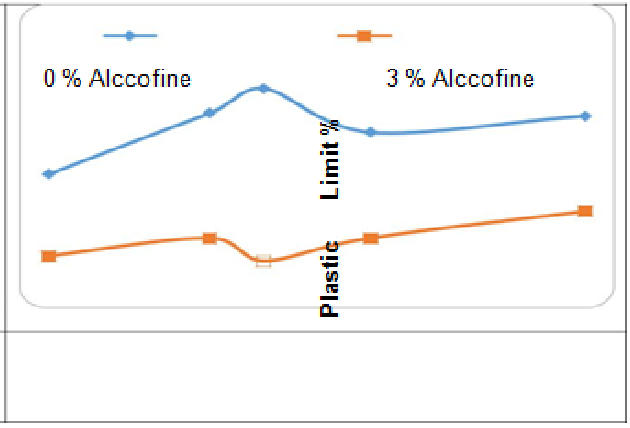

Fig – 1.3: Plastic Limits For Soil/Soil-Pond Ash–Alccofine Mixes

8.1.Maximum Dry Density & Optimum Moisture Content

The variation of maximum dry densities (MDD) of soil-pond ash mixtures with alccofine contents is presented in Fig. Generally,-MDD values-increased-with higher admixture contents which are due to the presence of pond ash/ash particles-filling-the voids within, the, soil. The MDD increased from 1.42 to 1.64Mg/m3 at 30% pond ash and 3% alccofine contents and later reduced to 1.62Mg/m3 at 50% pond ash and 3% alccofine treatment. The reduction may be due to the minimal effect of alccofine (with little calcium) on the workability of the stabilized soil. Pond ash occupying the void within the soil matrix and, in addition, the flocculation and agglomeration of the clay particles due to ion exchange.

Table - 1.3: Maximum Dry Density & Optimum Moisture Content Test Results for Soil–Pond Ash–Alccofine

Pond Ash Content (%)	Alccofine (%)			
	0		3	
	MDD (g/cc)	OMC (%)	MDD (g/cc)	OMC (%)
0	1.42	28	1.55	38
15	1.44	31	1.57	41
20	1.48	33	1.61	45
30	1.51	37	1.64	48
50	1.53	30	1.62	40

Table - 1.4: Unconfined Compressive Strength (7, 14 & 28 Days Curing) Test Results for Soil Pond Ash–Alccofine Mixes

Pond Ash	After 7 – days Curing		After 14 – days Curing		After 28 – days Curing	
	Alccofine (%)		Alccofine (%)		Alccofine (%)	
	0	3	0	3	0	3
0	178.38	582.25	189.93	873.59	220.1	980.65
15	288.39	568.14	359.35	922.97	643.9	1027.9
20	450.25	731.91	473.44	906.38	747.5	1197.6
30	693.04	985.46	504.17	1016.25	940.9	1347.6
50	533.35	822.78	629.41	1326.37	1019	1278.7

Table - 1.5: California Bearing Ratio (Unsoaked & Soaked) Tests Results for Soil-Pond Ash-Alccofine Mixes

Pond Ash content (%)	Alccofine (%)			
	Unsoaked		Soaked	
	0	3	0	3
0	5.15	17.77	4.64	16
15	10.85	21.94	9.77	19.75
20	17.51	27.5	15.76	35.74
30	21.89	46.12	19.7	41.5
50	22.57	36.21	20.3	32.59

9. Conclusion

The preliminary investigation conducted on the natural sand stabilized with pond ash and alccofine. The natural soil. has .high. moisture-content of 35% because, it was, collected during, the-rainy period. It has liquid limit of 63%, plastic limit of 27%, plasticity index of 36%, linear shrinkage of 17%, free swell of 75%, specific gravity of 1.94 and NBRRI Classification of high swell potential. All these values indicate that the soil is highly plastic with about 71% of the soil particles passing the B. S. No 200 sieve. The strength characteristics are also very low, thereby rendering the soil unfit for sub-base or road base courses.

In an effort to raise the soil's suitability for engineering use, the air dried samples were treated with OPC/ALCCOFINE in stepped concentration of 0, 2, 4, 6, and 8% by dry weights of the soil. The tests conducted showed that the liquid limit of the natural soil increased from 63% to 77% at 30% pond ash & 3% alccofine. The plastic limit, however, decreased from 26.6% for the natural soil to 21.4% at 6% OPC/4% ALCCOFINE. The plasticity index values for all the concentration of the additive exceeded the 30% value prescribed for sub-grade materials by the Nigeria General Specification (1997).

The MDD increased with higher additive blends and compactive efforts; which is in conformity with the same trend reported by Osinubi (1999a), Osinubi et al. (2007b), Staphen (2005) and Akinmade (2008). The peak MDD values recorded for BSL, WAS and BSH compactive efforts are respectively 1.4, 1.5 and 1.6Mg/m^3 at 30% pond ash & 3% alccofine treatment. The OMC, on the other hand, decreased with higher compactive efforts but increased with higher ALCCOFINE contents. The decrease may be due to the effect of breakdown of the flocculated aggregates and elimination of large pores, when higher compactive energies were used. The optimum moisture content values at the natural states increased from 24, 21 and 19% to 40, 38 and 33% when compacted using BSL, WAS and BSH energies at 8% OPC/6% ALCCOFINE, 50% pond ash & 3% alccofine and 30% pond ash & 3% alccofine, respectively.

The unconfined compressive strength (UCS) values for natural-soil-compacted with-BSL, WAS and BSH. energies at 7 days curing period are 179, 381 and 750kN/m^2 respectively and increased to 986, 1436 and 1650kN/m^2 at 30% pond ash & 3% alccofine treatment. The values of UCS for both BSL and WAS fell short of the requirement based on Road Note 31 (TRRI, 1977) requirement for economic range of OPC stabilization. However, the UCS value of the BSH compaction could be acceptable for base courses of pavements. The 28 days curing period UCS values obtained showed that the OPC/ALCCOFINE blend has a long term advantage in terms of strength gain. There were tremendous increments in the values of UCS from their natural states. The 28 days curing period UCS produced a peak value of 2616kN/m^2 at 30% pond ash & 3% alccofine for BSH compaction, showing that the soil treated with this blend can be used (at BSH compaction) as base course of pavement material.

The unsoaked CBR values of 5, 7 and 11% (for the natural-soil) compacted with BSL, WAS and BSH energy efforts, respectively, increased to 46, 77 and 83% at 30% pond ash & 3% alccofine. The 24 hours soaked-CBR values recorded peak values of 42, 66 and 66% with BSL, WAS, BSH energies, respectively, which showed about 10-15% decrease from the unsoaked CBR values. The CBR values of 66% with BSH compaction at 30% pond ash & 3% alccofine blend can be used as sub base material because it meets the 29% recommended values for sub-base by the Nigerian General Specification (1997). Also the 42% recorded with BSL compaction at 30% pond ash & 3% alccofine treatment meets the 15% recommended for subgrade material by the Nigerian General Specification (1997).

The resistance-to-loss in-strength of the soil increased, from 13, 7, and 15% for the natural soil to peak values of 42, 13 and 71% for BSL, WAS and BSH energies at 50% pond ash & 3% alccofine, 8% OPC/0% ALCCOFINE and 30% pond ash & 3% alccofine, respectively. Only 71% resistance-to-loss in-strength (29% loss-in-strength) at 30% pond ash & 3% alccofine with BSH compaction is close to the limiting value of 80% resistance-to-loss in-strength (Ola, 1983) based on 4 days soaking. The 6% OPC/6% ALCCOFINE treatment of the soil can be used, at BSH compaction, for sub-base material because the soil was subjected to a harsher condition (of 7 days soaking) and due to the time dependent gain in strength advantage of the pozzolana.

10. Recommendation

Based on the results obtained, the optimum blend of 30% pond ash & 3% alccofine treatment on the black cotton soil is to be used as sub-base material when compacted with the British Standard heavy energy.

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