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An experimental analysis of black cotton soil with pond ash – A sustainable approach

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Abstract - *Black cotton soil propensity to swell when it comes in contact with water and shrinks when water dries out, it causes serious problem to civil engineering structure. So stabilization with any admixture of these soils can enhance their properties and behavior. Soil stabilization is the physical, chemical or mechanical process of improving soil properties. In recent days, industrial waste has become increasingly important as a geotechnical material. Pond ash is the waste produced by the thermal power plant that is disposed of in the pond and is of no value. It is slurry in the form of (liquid). It can be used as an admixture to boost soil characteristics after drying.*

The current study addresses the laboratory test carried out on pond ash soil and the results obtained are recorded. The tests are performed to verify the impact of pond ash after mixing with soil, such as the Standard proctor test, Atterberg's limit, free swell test, California bearing ratio. In this research, black cotton soil is applied with 10 percent, 20 percent, 30 percent and 40 percent pond ash. From various experiments, it is found that the plastic limit is increased when 30% pond ash is applied, and the liquid limit has decreased. The strength of black cotton soil is then increased, and pond ash can be used for the process of soil stabilization.

Key Words: **Black cotton soil, Pond ash, soil Stabilization, Sustainability, CBR**

1. INTRODUCTION

Soil stabilization is a general term used to describe any physical, chemical, mechanical, biological or combination method of altering natural soil properties to achieve engineering objectives. It is the modification of soil characteristics. Stabilization can increase a soil's shear strength, and also regulates the soil's shrink-swell behavior, thus improving the ability of the load bearing.

Benefits of soil stabilization

- Reduction in plasticity and permeability can be accomplished by stabilization.
- It is possible to boost strength characteristics and bearing capacity.
- Stabilization decreases the compressibility of the soil and can also minimize the settlement of the soil
- By incorporating various admixtures, soil shrinkage and swelling properties are enhanced.
- Improvement in soil durability.
- With the aid of stabilization, soil waterproofing can be achieved.

Expansive soils, also referred to as swell-shrink soils, appear with changes in moisture content. As a consequence of this soil variation, there is considerable distress in the soil, which is then accompanied by damage to the overlying structures. One of India's main soil deposits is black cotton soil. Its color is black. When exposed to changes in moisture content, they display a high rate of swelling and shrinkage and have therefore been found to be most problematic from the perspective of engineering.

The montmorillonite rate is more in black cotton soil that causes expansion and crack occurs in soil without any construction hazardous notice. Building work on this type of soil is very difficult and foundation cracking takes place. Therefore, in order to prevent damage to the structure, it is important to enhance the properties of such soil.These kinds of soils are considered potential natural hazards, which can cause significant damage to the buildings built on them if not managed, as well as loss of human life. These types of properties are shown in general by soils whose composition includes the presence of montmorillonite. Harm due to the swelling-shrinking action of expansive soils has been prominently observed in the last few decades in the form of cracking and breaking down of roadways, channel and reservoir linings, pavements, building foundations, water lines, irrigation systems, drainage lines, and members of the slab-on-grade.

In the power generation scenario, coal is the main energy source not only in India but also in many other nations. In India, more than 60% of the electricity generated is from coal. So, in abundance, fly ash, bottom ash and pond ash are available.

Pond ash is the waste produced from a thermal power plant that is disposed of in the pond in the form of slurry (liquid). It is of no further use and is regarded as a waste material. It can be used as an admixture to improve the soil characteristics after drying. Pond ash also has a good water absorption property, so it can be used for filling purposes where the water table is at a higher level. Pond ash is important for soil waterproofing and infiltration reduction. So, in water logged areas, it can also be favored.

As energy generation is increasing day by day due to rapid industrialization, this energy generation by numerous power plants causes industrial waste production. The use of coal to

generate electricity results in the production of almost 100 million tons of coal ash per year.
In India, 65 percent of all power stations to be built in the next 3 years will be thermal power stations, with 75 percent of them using domestic coal. Coal, the cheapest source of energy, will remain the "King" for near-future power generation, producing almost 100 million tones of fly ash each year. The handling of this waste material is a big issue, because these materials (pond ash, fly ash & bottom ash) are of no further use, their decomposition causes a lot of trouble. These materials can therefore be used as a soil stabilizer or can also be used as material for earth filling.

1.1 Material Collections

From Sirsa gate,Bhilai, the pond ash sample is collected. There is a set of soil samples from Singar Bhata,
Raipur. Removal of organic waste, rocks and litter from the surface of the soil sampling area before collecting the sample. Pick the sampling spot from around 5-6 locations in a zigzag manner. Collect all the samples in a gunny bag or bucket.
The organic residues such as tree leaves, dung, gravel, stones and other unwanted material should be kept out after complete collection of soil samples from the field and samples should be prepared for laboratory analysis by taking the following steps like drying, grinding, sieving, mixing, partitioning, weighing, storing and labeling.

2. METHODOLOGY

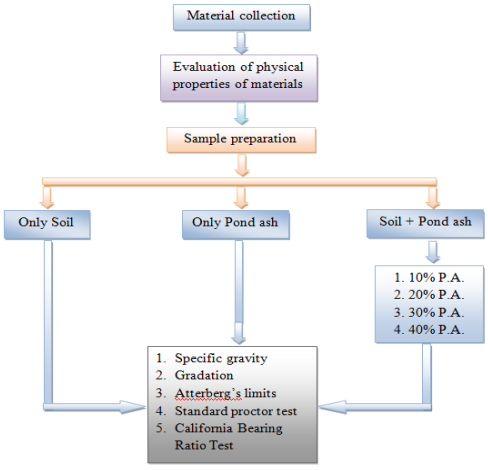

Fig 1- Block Diagram of Evaluation of soil properties

Following tests has been carried out on the soil sample and mixture of soil and pond ash:

1) **Standard proctor test:** This test is conducted to find out the maximum dry density and optimum water content of soil and mixture of soil and pond ash.
   - No. of layers- 3
   - No. of blows per layer- 25
   - Height of fall of rammer: 30cm
   - Weight of rammer: 2.6 kg
2) **Casagrande liquid limit**: Liquid limit test is conducted to determine the water content at which change in behavior of soil and mixture of soil and pond ash takes place. Liquid limit is the boundary between liquid and plastic state.
   - Casagrande cup
   - 425-micron sieve
   - Grooving tool
   - Knife
   - ASTM tool
   - Mixing and storage bowl
   - Balance Container
3) **Plastic limit**:
   Water content between liquid state and semi solid state is called as plastic limit. It is the minimum water content at which soil can be rolled into 3mm diameter thread without crumbling.
   - Apparatus:
   - 425-micron sieve
   - Glass plate
   - Container
   - Drying oven
4) **Free swell test:**
   This is conducted to find the shrinking and swelling behavior of any material.
   Apparatus:
   - 425 micron sieve
   - Graduated glass cylinder

5) Pycnometer test:
This test is conducted to find out the specific gravity of the material. Specific gravity is useful to find specific surface area. As the fines increases specific gravity also increases.

6) California bearing ratio test:
This test is conducted to find out the penetration resistance of soil. It is conducted by CBR apparatus which consist of proving ring and dial gauge.
No. of layers- 5
No. of blows per layer- 56
Height of the fall of rammer: 45cm
Weight of rammer: 4.9 kg

7) Soil gradation:
Soil gradation is a classification of a coarse-grained soil that ranks the soil based on the different particle sizes contained in the soil. Soil is graded as either well graded or poorly graded. Soil gradation is determined by analyzing the results of a sieve analysis or a hydrometer analysis.

3. RESULTS

Sieve analysis of soil sample

From table no 1 sieve analysis calculation we found D_{10} D_{30} and D_{60}

D_{10} = 0.386; D_{30}= 1.29; D_{60} = 3.428

Co-efficient of Uniformity (C_u) = $\frac{D60}{D1o} = \frac{3.428}{0.386}$ = 8.88

Co-efficient of Curvature (C_c) = $\frac{D30^2}{D60 \times D10} = \frac{1.29^2}{3.428 \times 0.386}$ = 1.258

Because C_U>6, C_C lies between 1 & 3: So, the type of soil is well graded sandy soil.

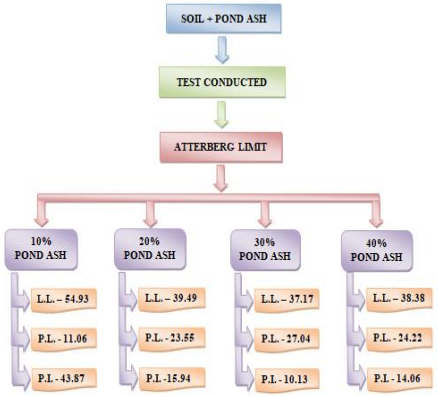

Fig – 2 Block diagram of atterberg's limit

Fig 2 showing the result of atterberg's limit test conducted on different samples of soil and pond ash.The liquid limit value is decreasing with increase in percentage of pond ash upto 30%. At 10% addition, highest liquid limit value is obtained. Addition of 30% pond ash shows the best value at which liquid limit is minimum.Plastic limit is increasing with increase in pond ash percentage upto 30% addition. The highest plastic limit value is obtained at 30% pond ash addition which shows the high strength of the sample and it can resist heavy loads as well.

Fig 3 explains the optimum moisture content at 10% pond ash is highest and then uneven result is obtained. The optimum moisture content and maximum dry density in which uneven result is obtained. Highest optimum moisture content is obtained at 10% pond ash addition and maximum dry density is obtained at 20% addition. The behaviour obtained is inconsistent.

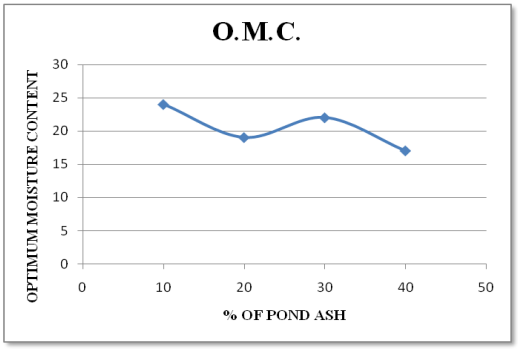

Fig - 3 Optimum moisture content & 10 % pond ash

Figure 4 is showing maximum dry density and % pond ash relation. At 20% addition of pond ash maximum dry density is highest.

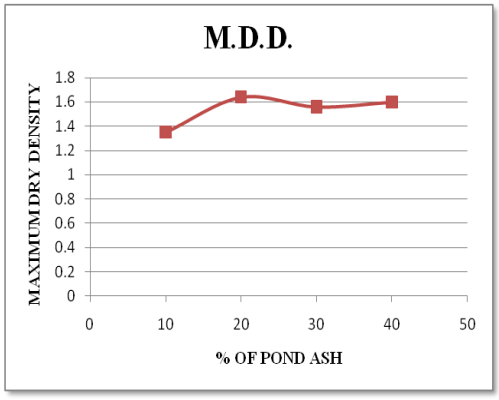

Fig – 4 maximum dry density and % pond ash relation

Fig 5 shows the California bearing ratio value which shows the CBR increases when 20% pond ash is added and then decrease at 30% pond ash addition. Highest California bearing value is obtained at 40% pond ash which is suitable for pavement construction.

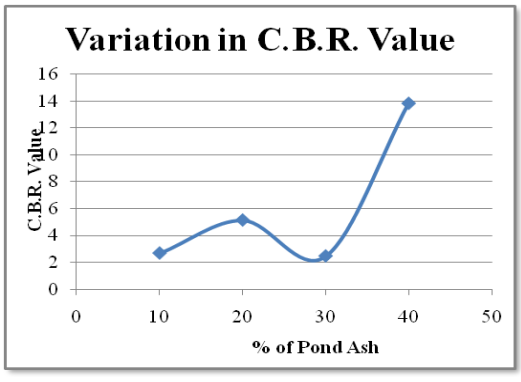

Fig 5 The California bearing ratio value

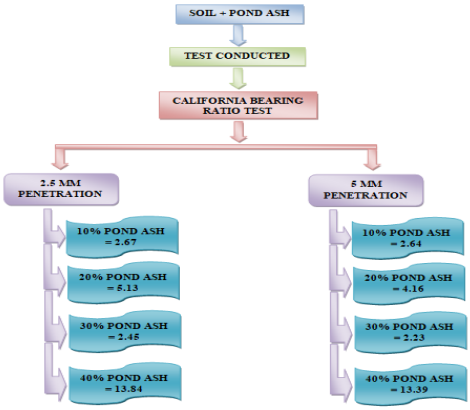

Fig – 6 CBR test results

4. CONCLUSION

From this study it is found that the 30% addition of pond ash is giving high plasticity value which shows the higher strength of soil and compactness of material. Liquid limit value is low which shows less water absorption, so swelling of soil will be low and structure can withstand without failure. Following results were obtained-

- O.M.C. at 10% pond ash addition increases and then starts decreasing upto 30% addition.
- M.D.D. increases at 10% addition of pond ash and then start decreasing.
- CBR value for 40% addition is very high which shows higher strength and can be used as subgrade also.
- Liquid limit first increases then started decreasing.
- Plastic limit increases upto 30% and then decreases.
- Plasticity index decreases with increase in pond ash which shows good quality of mix.

With this results and conclusion, this study says that 30% pond ash can be used for the method of strength enhancement and can be used in those regions where there is black cotton soil. In water logged areas, it can also be used.

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