Soil Stabilization of Clayey Soil Using Coal Ash and Stone Dust

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Abstract— In India the soil mostly present is Clay, in which the construction of sub grade is problematic. In recent times the demands for sub grade materials has increased due to increased constructional activities in the road sector and due to paucity of available nearby lands to allow excavate fill materials for making sub grade. In this study Stone Dust and Coal Ash is mixed with Parent Soil in various percentage (3%, 6%, 9%, 12%, 15% and 18%). The main objective of this study is to evaluate shear strength characteristics, CBR and Unconfined Compression behaviour of untreated and stabilized soil with Stone Dust and Coal Ash. Based on the results obtained from Modified Proctor compaction test, the ideal MDD and OMC value used for further, unconfined compression and CBR tests. The present investigation has therefore been carried out with waste materials like Stone Dust (SD) and Coal Ash (CA) which was mixed with soil to study improvement of weak sub grade in terms of compaction and strength characteristics.

Key words: MDD, OMC, CBR, UCS, Stone Dust and Coal Ash

I. INTRODUCTION

Clayey soil deposits occur in the arid and semi arid regions of the world and are problematic to engineering structures because of their tendency to heave during wet season and shrink during dry season. Clayey soils are a worldwide problem that poses several challenges for civil engineers. They are considered a potential natural hazard, which can cause extensive damage to structures if not adequately treated. Hence problematic soil like clayey soil must be adequately treated before the erection of structure. Wide range of soil modification method is available. Selection of appropriate method should be based on the type of soil and its characteristics, type of the construction, time available, associated cost. It has been observed that industrial by-products can cause drastic change in the soil properties in terms of strength characteristics, density, acidity etc. and also serves agricultural benefits by increasing crop yield. Moreover utilization of these products is a better solution to disposal than heaving them up on land.

II. OBJECTIVE OF THE STUDY

1) To check the ambit of reducing clayeyness and improving bearing capacity value by adding additives.
2) Also to establish the usage of Coal Ash and Stone Dust as an additive, thereby helping utilize it which otherwise always lies as waste product.

Moreover pavement on clayey soil requires a greater thickness of base and sub-base course which results increases the expenditure of project. To set right this problem it becomes mandatory to increase the strength of the soil which in-turn will help in lessening the thickness of the pavement layers and thus project cost.

III. MATERIAL COLLECTION

A. *Clayey Soil*

As a part of this investigation, the clayey soil was acquired from the site Karnal, Haryana. The clayey soil thus obtained was carried to the laboratory in sacks. The soil was oven dried before determining any geotechnical properties. The various geotechnical properties of the procured soil are as follows:

S.No.	Parameters	Result
1.	Light Compaction Test MDD (gm/cc) OMC (%)	 1.61 24.2
2.	Liquid Limit (%)	49.67
3.	Plastic Limit (%)	20.69
4.	Plasticity Index (%)	28.98
5.	Specific Gravity	2.66
6.	Indian Soil Classification	CI

Table 1: Physical Properties Of Soil

B. *Coal Ash*

The coal ash was brought here from the Thermal Power Plant, Panipat. The coal ash was oven dried and was passed through 425 micron sieve. The coal ash was mixed with parent soil in percentage of 3%, 6%, 9%, 12%, 15% and 18%.

Principal Components	Silica, Alumina, Iron Oxide, Carbon
Color	Gray to Black (Depending upon Carbon Oxide Content)
Cleavage	Perfect
Specific Gravity	2.21
Diagnostic Properties	Cleavage, Specific Gravity, Low Hardness
Chemical Composition	SiO_2, Al_2O_3, Fe_2O_3, CaO ,
Uses	Cement production, Structural fills, Soil Stabilization

Table 2: Properties Of Coal Ash

C. *Stone Dust*

Stone dust was purchased from Distt. Yamunanagar for experimental research and was mixed with parent soil in percentage of 3%, 6%, 9%, 12%, 15% and 18%. The specific gravity of the stone dust is 2.87.

Angular crushed stone is the key material for macadam road construction which depends on the interlocking of the individual stones' angular faces for its strength. Crushed natural stone is also used similarly without a binder for riprap, railroad track ballast, and filter stone. It may also be used with a binder in a composite such as concrete, tarmac, or asphalt concrete.

S.No.	Parameters	Result
1.	Liquid Limit	Non Plastic
2.	Plastic Limit	Non Plastic
3.	Specific Gravity	2.87
4.	Color	Grey

Table 3: Physical Properties of Stone Dust

IV. METHODOLOGY

A. *Compaction Test*

This Phase of Study involved a detailed investigation of the compaction characteristics of the parent soil and blended sample containing different percentage of coal ash and stone dust contents, in order to obtain the optimum moisture contents and maximum dry densities. The optimum moisture contents thus obtained is used in preparing samples for Unconfined Compressive Strength Test. This test confirms to IS: 2720 (Part 8) 1983.

B. *Unconfined Compressive Strength*

After the compaction test the compressive strength of the sample is measured. Cylindrical specimen is compacted by static compaction in 3.8 cm diameter and 7.6 cm high mould. The inner surface of the mould is lubricated with mobile oil so as to extrude the sample from mould with minimum disturbance. The sample is placed inside the specimen mould in seven layers using spoon, leveled and gently compacted. Pressure pad will be inserted into the mould and the whole assembly will be statically compacted in loading frame to the desired density. The sample is to be kept under static load for not less than 10 minutes in order to account for any subsequent increase in height of sample due to swelling. The sample will then be removed from the mould with the help of sample extruder. Initial dimensions are measured.

C. *California Bearing Ratio (Cbr) Test*

The CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. The CBR test may be conducted in re-moulded or undisturbed specimen in the laboratory. The test is simple and has been extensively investigated for field correlations of flexible pavement thickness requirement. The test is conducted by causing a cylindrical plunger of some diameter to penetrate a pavement component material at 1.25mm/minute. The loads, for 2.5mm and 5mm are recorded. This load is expressed as a percentage of standard load value at a respective deformation level to obtain C.B.R. value.

V. TEST RESULT AND DISCUSSION

A. *Effect of Coal Ash and Stone Dust on MDD and OMC*

From the proctor test, it has been observed that the maximum dry density (MDD) increases by the addition of coal ash in parent soil up to 9 percent, after that it gradually decreases and the optimum moisture content varies at each percentage. Initially the OMC & MDD of the parent soil were 24.2% & 1.61 gm/cc respectively according to the proctor test conducted. But with further addition of Coal Ash, it is observed that the maximum dry density starts to decreases but the compared to parent soil it still increases. It is also been observed that the optimum moisture content varies with addition of coal ash.

Further if we replace the coal ash with different material such as Stone Dust, the MDD and OMC of the clayey soil shows tremendous increases as compared to the coal ash. From the proctor test, it has been observed that the maximum dry density (MDD) increases by the addition of Stone Dust in parent soil up to 12 percent, after that it gradually decreases and the optimum moisture content varies at each percentage. With further increment of stone dust in soil the MDD starts to decreases but still have greater value then parent soil and Coal ash. The comparison of MDD and OMC for Coal Ash and Stone dust are given in Figure 1 and Figure 2.

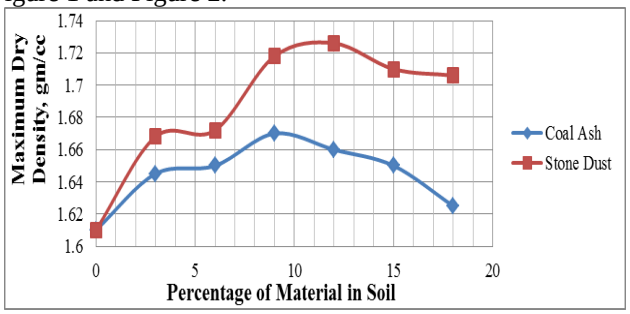

Fig. 1: Effect of Coal Ash and Stone Dust on MDD at Different Percentage

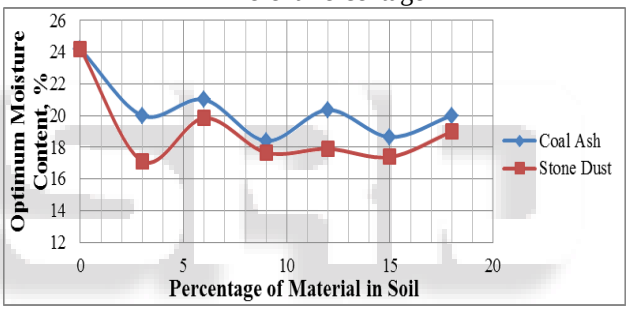

Fig. 2: Effect of Coal Ash and Stone Dust on OMC at Different Percentage

B. *Effect of Coal Ash and Stone Dust on UCS*

From UCS test conducted for the same sample as described in proctor test, the strength of samples shows increasing tendency for some samples with the increment of Coal Ash and Stone Dust percentage in the soil i.e.; for parent soil strength obtained 1.18 kg/cm^2. For the Coal Ash-Soil mixture and Stone Dust-Soil mixture shows incremental results in the compressive strength as compared to the parent soil. The comparison of UCS for Coal Ash and Stone dust are given in Figure 3.

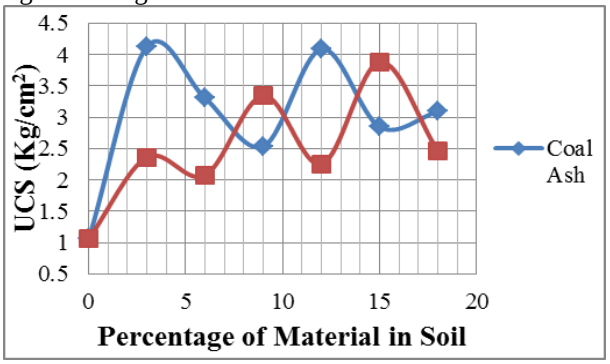

Fig. 3: Effect of Coal Ash and Stone Dust on UCS at Different Percentage

C. Effect of Coal Ash and Stone Dust on CBR

From CBR test conducted for the same sample as described in proctor test, the CBR value of all the samples have higher value than the CBR value of Parent Soil. Initially the CBR value of Parent soil is 0.89%. But with addition of Coal Ash into Soil and Stone Dust into Soil shows incremental results in the CBR value as compared to the parent soil. The comparison of CBR for Coal Ash and Stone dust are given in Figure 4.

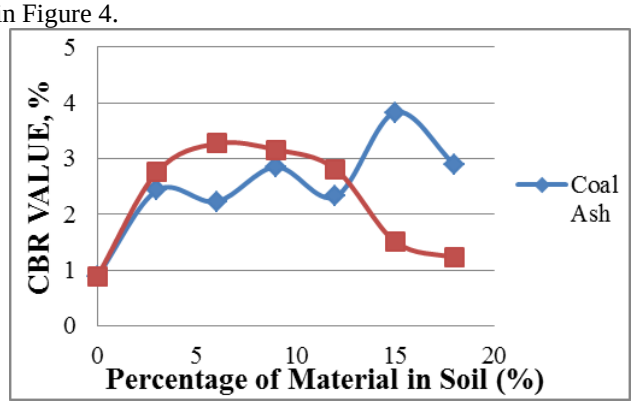

Fig. 4: Effect of Coal Ash and Stone Dust on CBR at Different Percentage

VI. CONCLUSION

In this thesis, the comparative study has been done of Soil-Coal Ash mixture and Soil-Stone Dust mixture to find out the compaction characteristics, strength parameter and CBR value of this soil mixed with different material at different percentage. Based on this the following conclusion can be made on the basis of test performed in laboratory: -

1) With the addition of Coal Ash into the soil the maximum dry density increases up to 9%. But with further addition of coal ash in the soil the maximum dry density starts to decreases while optimum moisture content shows varying behavior for all the samples.
2) When we replace the coal ash with stone dust the dry density increases drastically with decrease in moisture content.
3) Based on the compaction test, the maximum dry density of soil stabilized with stone dust has much greater value the soil stabilized with coal ash.
4) It was also observed that C.B.R. value was increase for both coal ash and stone dust addition to clayey soil. The increase in C.B.R. value is an indication of improvement of soil properties and its strength to counter the resistance to penetration resulting in a decrease in pavement thickness and reduction in cost of construction of pavement.
5) In UCS, both the Coal ash and Stone dust stabilized soil shows increment in the strength of the soil but it shows varying nature it may be due to maximum dry density and optimum moisture content.
6) Coal ash has several advantages for the construction of embankments. The main advantages are its low unit weight and high shear strength. The disadvantages are due to its fine grained non - cohesive nature, is easily subject to erosion by wind or water.

REFERENCES

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[4] Cokca (2001) found out that swelling pressure decreased by 75% after 7 day curing, and 79% after 28 day curing when soil specimens were treated with 25% Class C Coal ash (18.98% of CaO).
[5] Pandian et al. (2001) made an effort towards stabilization of clayey soil by using Class F Coal ash. He found that coal ash can make for an effective additive when he saw that with 20% coal ash content, the CBR value of Black cotton soil improved (about 200%) significantly.
[6] Satyanarayana et al. (2004) aimed to study the mutual effect of addition of lime and coal ash on the engineering properties of the clayey soil.
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[8] Baytar (2005) contemplated the stabilization of clayey soils using desulphogypsum and coal ash acquired from a thermal power plant by 0 to 30%. A variable percentage of lime (0 to 8%) was appended into the clayey soil-desulphogypsum-coal ash mixture.
[9] Amu et al. utilized coal ash and cement mixture for the stabilization purposes of clayey soil.
[10] Wagh (2006) utilized rock flour, lime and coal ash independently, furthermore in diverse extent to stabilize the black cotton soil from Nagpur Plateau, India.

