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Assessing the Suitability of Pondash Mixed Marble Dust on Expansive Soil as Subgrade

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ABSTRACT: The life of road depends on strength of the subgrade soil and traffic density. The subgrade soil is not uniform throughout the alignment of the road. Generally poor subgrade soil having soaked California Bearing Ratio (CBR) value less than 2% is replaced by good quality subgrade material. The black cotton soil which is an expansive soil covers 0.7×10^6 km² approximately 20-25 % land area in India. Pond ash is the by-product from thermal power stations, which is nearly 5000 tonnes per year. Marble dust is the by-product during cutting of marble and the amount of marble dust generated every year is 5-6 million tonnes per year. These wastes are mostly responsible for pollution of air, soil and water. And these wastes require huge space for their disposal. In this paper, sub-grade characteristics of black cotton soil blended with pond ash and marble dust in different proportions had been studied. Usage of pond ash and marble dust as fill material solves the disposal problems and the purpose of mixing these admixture with pond ash is to check the strength, volume stability (shrinking and swelling), etc.

KEYWORDS: Pondash, Black cotton soil, marble dust, Pavement design

I. INTRODUCTION

Soils with low-bearing capacity can be strengthened economically for building purposes through the process of “soil stabilization” using different types of stabilizers. Soil bed should bear all generated stresses transmitted by shallows or piles. The soil often is weak and has no enough stability in heavy loading. In this regard, it is necessary to reinforce and or stabilize the soil. With the increased global demand for energy and increasing local demand for aggregates, it has become expensive from a material cost and energy use standpoint to remove inferior soils and replace them with choice, well-graded aggregates. One way to reduce the amount of select material needed for base construction is to improve the existing soil enough to provide strength and conform to engineering standards. This is where soil stabilization has become a cost-effective alternative.

In India, thermal power is the chief source of energy and produces nearly 70 percent for total energy production. The coal ash generated from all the existing thermal power plants is over 100 million tonnes per year. Since the production of high ash content and low percentage utilization, most of the fly ash has to be suitably disposed off on land by creating an engineered ash pond to take care of environmental concerns. The fly ash as well as bottom ash produced by the plant is generally disposed of in an ash pond. This ash is called pond ash. This study deals with finding the suitability of pondash mixed marble dust on expansive soil as subgrade soil. The characteristics of soil when mixed with pond ash and marble dust in various percentages by weight are also checked in the current study. The Marble dust is generated as a by-product during cutting of marble. The waste is approximately in the range of 20% of the total marble handled. The amount of marble dust generated every year is very substantial being in the range of 5-6 million tonnes.

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II. RELATED WORK

Bibha Mahto, et .al (2015) deals with use of pond ash and RBI Grade 81 for enhancement in CBR values of clayey and silty soil. It was found that with the addition of Pond ash along with RBI Grade 8, the C.B.R. increased up to a certain limit but after that the C.B.R. decreased even on more addition of pond ash.

Girish Dinkar Patil, et.al (2015) study deals with improving the properties of black cotton soil through addition of Pond ash as industrial waste. The soaked CBR value of untreated soil is 0.61%. The soaked CBR value of mix soil: Pond Ash in the proportion of 80:20 is 1.53% which is increased by 92% in comparison with untreated soil. Where Stabilized pavement is designed by using industrial waste in the sub-grade the total thickness of pavement is decreased by 150 mm, as comparison with conventional flexible pavement.

K. A. Patil, et.al (2013) Study the Effect of Pond Ash and RBI Grade 81 on Properties of Subgrade Soil and Base Course of Flexible Pavement. The geotechnical properties of clayey soil improve significantly due to addition of pond ash and RBI Grade 81. The RBI Grade 81 and pond ash help to reduce the swelling characteristics of clayey soil as the DFS index reduces. The use of pond ash for road construction work reduces environmental pollution up to certain extent.

Raju Sarkar, et.al (2013) paper deals with geotechnical characteristics of the pond ashes collected from Badarpur, Dadri and Rajghat Power Plant located in the National Capital Region, Delhi. Since the proposed study is based on the characteristics of pond ashes mixed with another waste - marble dust, another waste, which is generated as a by-product during cutting of marble, hence its properties has also been investigated. In the California Bearing Ratio tests, the value of CBR increases with the increase of marble dust content.

III. MATERIALS USED

Expansive Soil

Black cotton soil (BC soil) is a highly clayey soil. The black color in Black cotton soil (BC soil) is due to the presence of titanium oxide in small concentration. The Black cotton soil (BC soil) has a high percentage of clay, which is predominantly montmorillonite in structure and black or blackish grey in color. Expansive soils are that clay soils which exhibit significant volume changes because of soil moisture variation. Expansive soils are a worldwide problem that poses several challenges to civil engineers. And the general properties of black cotton soil are given in the table 1.



Fig.1 Black cotton soil

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Vol. 6, Issue 5, May 2017

Table 1: Properties of Blackcotton soil

Property	Value
Specific Gravity	2.35
Atterberg Limits	
Liquid limit	53%
Plastic limit	32.7%
Particle Size Distribution	
Gravel (%)	0
Sand (%)	4
Silt (%)	56
Clay (%)	40
Unconfined Compressive Strength (KN/m ²)	8.7
Compaction characteristics	
Optimum moisture content (%)	22%
Maximum dry density (g/cc)	1.7
California Bearing Ratio	2.7%
Permeability (cm/sec)	4.3×10^{-4}

Pond Ash

In India, thermal power is the chief source of energy and produces nearly 70 per cent for total energy production. The coal ash generated from all the existing thermal power plants is over 100 million tonnes per year. And the general properties of pond ash are given in the table 2.



Fig. 2 Materials (a) Fly ash (b) Bottom ash

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(An ISO 3297: 2007 Certified Organization)

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Vol. 6, Issue 5, May 2017

Table 2: Properties of Pond ash

Property	Value
Specific Gravity	2.38
Atterberg Limits Liquid limit Plastic limit	- Non-Plastic
Particle Size Distribution Gravel (%) Sand (%) Silt (%) Clay (%)	0 95 5 0
Compaction characteristics Optimum moisture content (%) Maximum dry density (g/cc)	18% 1.82

Marble Dust

Marble dust is generated as a by-product during cutting of marble. The waste is approximately in the range of 20% of the total marble handled. The amount of marble dust generated every year is very substantial being in the range of 5-6 million tonnes. And the general properties of marble dust are given in the table 3.



Fig. 3 Marble dust

Table 3: Properties of marble dust

Property	Value
Specific Gravity	2.53
Atterberg Limits Liquid limit Plastic limit	- Non-Plastic
Particle Size Distribution Gravel (%) Sand (%) Silt (%) Clay (%)	0 85 15 0

III. EXPERIMENTAL RESULTS

Compaction Characteristics

The variation in dry density and optimum moisture content with varying percentage of pondash was plotted as shown in Fig (a). The optimum percentage of pondash was fixed as 60% and the compaction tests of the expansive soil with varying percentage of marble dust were conducted. The variation in dry density and optimum moisture content with varying marble dust contents on optimum percentage of pondash on blackcotton soil was plotted as shown in Fig (b).

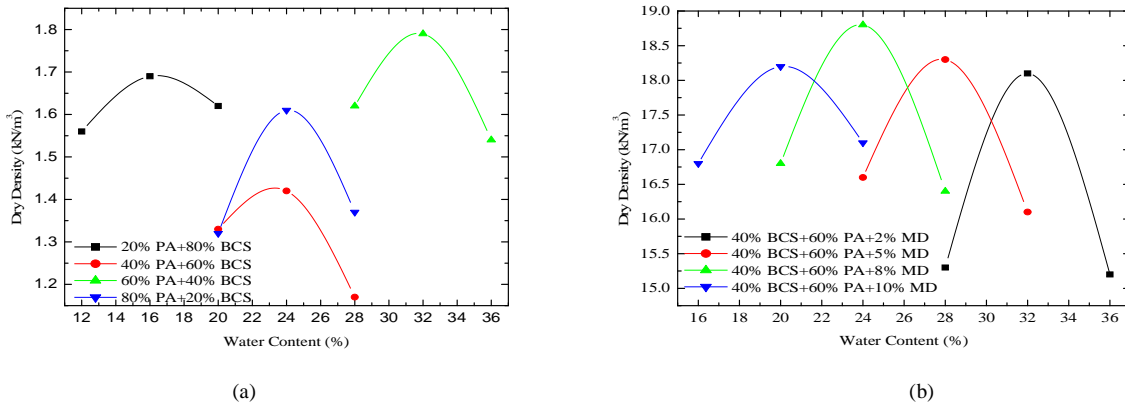


Fig 4: Compaction Characteristics (a) Drydensity Vs Watercontent graph of compacted with different percentage of pondash (b) Drydensity Vs Watercontent graph of compacted soil at different percentage of marble dust at optimum pondash

U.C.C Test Result

The variation in UCS with varying percentage of pondash was plotted as shown in Fig. (a). The optimum percentage of pondash was fixed as 60% and the unconfined compressive strength of the expansive soil was determined at optimum pondash content and varying percentages of marble dust. The variation of unconfined compressive strength with varying percentage of marble dust on optimum percentage of pondash on blackcotton soil are shown in fig. (b).

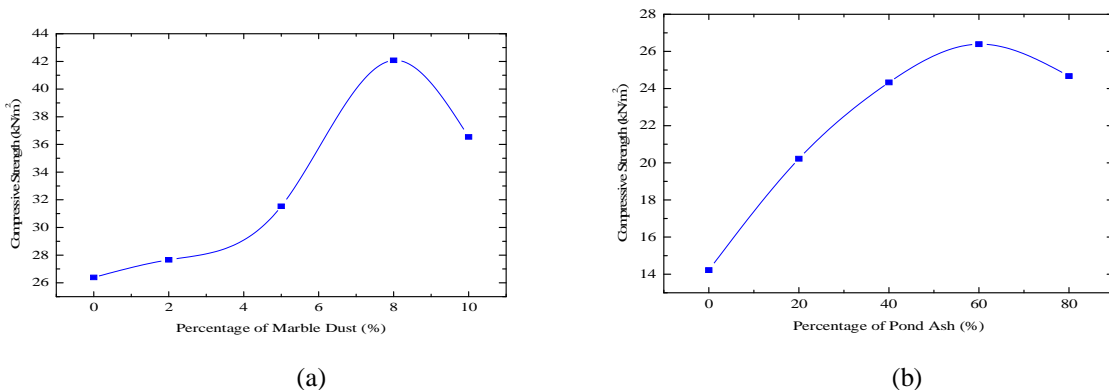
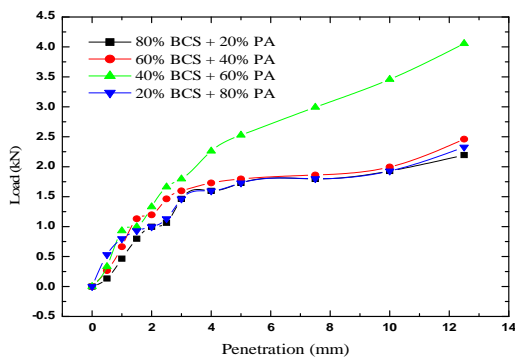


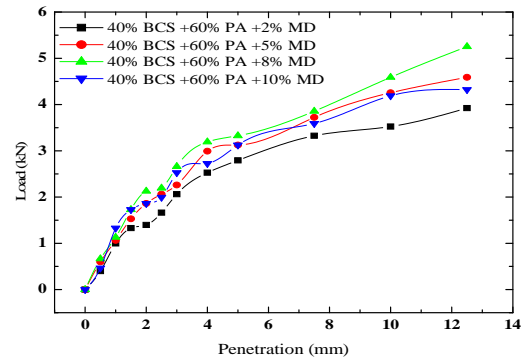
Fig 5: UCS Curve (a) UCS Curve of soil with different percentage of pondash (b) UCS Curve of soil with different percentage of marble dust to optimum pond ash

California Bearing Ratio Test

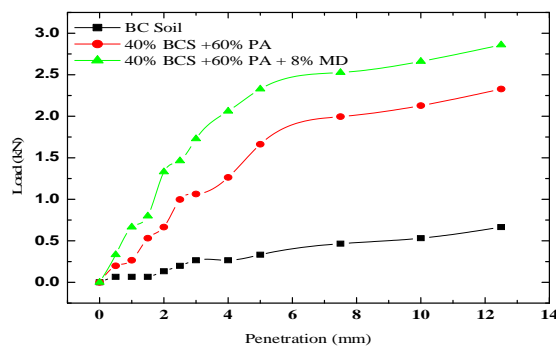
Then Unsoaked and soaked CBR tests were carried out. CBR test were most important test because as per IRC 37 the pavement thickness depends upon CBR value of soil. The test was conducted on black cotton soil and in treated black cotton soil. The variation in CBR value with varying percentage of pondash was plotted as shown in Fig (a). The optimum percentage of pondash was fixed as 60% and the CBR value of the expansive soil was determined at optimum pondash content and varying percentages of marble dust. The variations of CBR value with varying percentages of marble dust on optimum pondash on black cotton soil are shown in Fig (b). The Load – Penetration graph of soaked normal black cotton soil, black cotton soil replaced with 60% pondash and treated with 8% marble dust are shown in Fig.(c).



(a)



(b)



(c)

Fig.6 Load - Penetration graph (a) Load - Penetration graph of compacted soil at different percentage of pondash (b) Load - Penetration graph of soil at different percentage of marble dust with optimum pondash (c) Load -Penetration graph of soaked normal soil and treated soil

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IV. DESIGN OF PAVEMENT SUBGRADE

Data considered for design of pavement is given below.

1. Dual 4 lane divided carriageway
2. Initial traffic in each direction in the year of completion of construction $A = 5200 \text{ CV/day}$.
3. Design life, $n = 15 \text{ years}$.
4. The traffic growth rate, $r = 7.5\%$
5. Vehicle damage factor, $f = 4.5$
6. Distribution factor, $D = 0.45$

$$N = \frac{[365 \times (1+r)^n - 1]}{r} \times A \times D \times F$$

$N = 100 \text{ msa}$

Cumulative standard axels $N = 100$ is taken in to consideration according to IRC 37 – 2001

Composition of pavement for untreated soil from plate (IRC 37 p.g.No. 31)

The thickness of untreated soil, having CBR value 2% is worked out as per IRC : 37

1. Bituminous surfacing = 50mm
 2. DBM = 195mm
 3. Base = 250mm
 4. Sub-base = 460mm
- Total pavement thickness = 955 mm

Composition of Pavement for Soil Treated with 60% of Pondash From Plate (IRC 37 p.g. No. 29)

For untreated soil, treated with pondash, having CBR= 8% corresponding thickness design is worked out as per IRC: 37.

1. Bituminous surfacing = 50mm
 2. DBM = 140 mm
 3. Base = 250 mm
 4. Sub-base = 200mm
- Total pavement thickness = 640 mm

Composition of pavement for soil treated with 60% of pondash and 8% marble dust from plate (IRC 37 No. 37)

For untreated soil, treated with pondash and coir fibre, having CBR= 10% corresponding thickness design is worked out as per IRC: 37.

1. Bituminous surfacing = 50mm
 2. DBM = 130mm
 3. Base = 250mm
 4. Sub-base = 200mm
- Total pavement thickness = 630 mm

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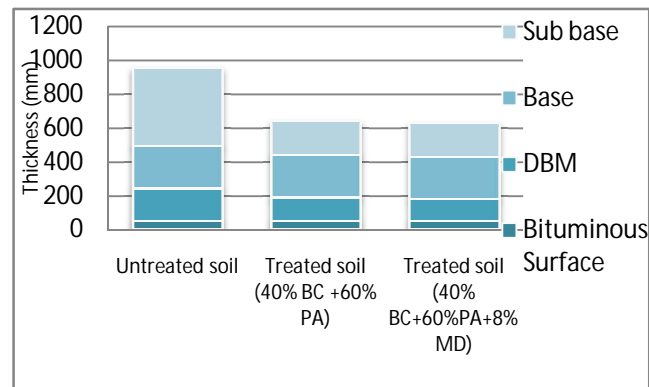


Fig.7 Comparison of Thickness of Natural & Treated Layer

Fig.7 shows the Comparison of Thickness of Natural & Treated Layer. The thickness of untreated soil is 955mm and the treated one is 630mm. This is because of increase in CBR value of sub-grade and total thickness of pavement is decreased by 325mm.

IV. CONCLUSION

- The MDD of the expansive soil increases while OMC decreases with the addition of marble dust to pond ash stabilized expansive soil.
- The optimum percentage of pond ash corresponding to both UCC and CBR test, for stabilizing the expansive soil was found to be 60%.
- The optimum marble dust content for the expansive soil at optimum pond ash was found to be 8%
- It is observed that by the addition of 60% of pond ash, the UCC of soil increased by 48%.
- It is observed that by the addition of 8% marble dust to optimum pond ash soil mix, the UCC of soil increased by 75%.
- There is a considerable increase in CBR value of the treated soil from 10% to 16.18% by the combined effect of pond ash and marble dust.
- Due to increase in the CBR value of subgrade, total thickness of pavement is decreased by 325mm.

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