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Effect of Pond Ash and RBI Grade 81 on Properties of Subgrade Soil and Base Course of Flexible Pavement

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***Abstract*—**This paper deals with use of pond ash and RBI Grade 81 for improvement in CBR values of clayey soil and grade-III materials used for base course of flexible pavement. The pond ash is a thermal power plant waste and RBI Grade 81 is chemical soil stabilizer. The geotechnical properties like Maximum Dry Density (MDD), Optimum Moisture Content (OMC), Unconfined Compressive Strength (UCS), CBR value and Differential Free Swell (DFS) index of soil are tested in the laboratory for different mixes of soil, pond ash and RBI Grade 81 for different proportions. The mixes of grade-III material, pond ash and RBI Grade 81 tested for CBR test. From the study it is found that the geotechnical properties of clayey soil are improved significantly, if pond ash added with RBI Grade 81. The optimum mix recommended for subgrade is soil: pond ash: RBI Grade 81 in proportions of 76:20:4. The CBR value of grade-III base course treated with 20% pond ash and 4% RBI Grade 81 is increased by 125.93% as compared to untreated grade-III base course.

***Keywords*—**Clayey soil, Geotechnical properties, Pond ash, RBI Grade 81™.

I. Introduction

THE development of any country depends on growth of industries and agriculture, which is governed by adequate power supply. To fulfill the requirement of power number of thermal power plants are started. From these power plants huge amount of waste like pond ash and fly ash are developed. The fly ash and pond ash are mostly responsible for pollution of air, soil and water. These wastes require huge space for their disposal. Therefore it is necessary to increase the reuse of these wastes in construction industry. The strength of subgrade and base course of road is measured in terms of California Bearing Ratio (CBR) value. The crust thickness of road section depends on CBR value of subgrade soil, base course and traffic intensity. The CBR value of clayey soil is poor and therefore it is not suitable as a subgrade material of road. If the subgrade soil is clayey, the crust thickness of flexible pavement increases due to less CBR value.

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To overcome this problem, the subgrade soil and base course material can be stabilized by using pond ash and RBI Grade 81. If the mix of pond ash and RBI Grade 81 used for stabilization of subgrade soil for the roads in nearby area of thermal power plants, the cost of construction can be reduced. The locally available clayey soil can be used as subgrade material. Also the base course material having CBR value less than required can be stabilized and thickness of road can be reduced.

Ahmed Ebrahim [1] studied the effect of steel slag on the mechanical properties of blended soil mixes with crushed limestone aggregates. These mixes are used for subbase materials in Egypt. The addition of steel slag and limestone improve the geotechnical properties of soil such as MDD, CBR and resilient modulus. The optimum ratio of steel slag and limestone crushed aggregates improve the subbase layer density, strength and failure resistance. Rafat Siddique [2], [8], [9], [10], [12] studied use of various waste materials like fly ash, bottom ash, foundry sand, cement kiln dust, wood ash and scrap tire rubber for Controlled Low Strength Material (CLSM). The fly ash is used mostly in construction applications, like in cement, concrete, structural fills, road base/sub base/pavement etc. Bottom ash is used for compacted fill, CLSM. R.K. Sharma et al. [3], worked on use of sand, rice husk ash and waste plastic fiber for improving compaction characteristics of clayey soil for use as subgrade material. The influence of different mix proportions of clays, sand, rice husk ash, on compaction and CBR values have been studied. The addition of rice husk ash in the clay and sand mix increases the OMC and decreases MDD. The addition of plastic fiber, rice husk ash and sand in the clay, leads to increase in the CBR value and reduction in permeability.

Kolay et al. [4] based on their experimental study found that the MDD for pond ash sample is increased, due to addition of pond ash in soil. While the OMC decreases with increase in the pond ash content. The UCS value for peat and pond ash mixed sample increases. The compressive strength of peat-pond ash sample almost doubled in comparison with original peat soil with addition of 20% pond ash of weight of modified soil. Aykut et al. [5], [7] studied the effect of fly ash stabilization on four different types of soft subgrades encountered using locally available fly ash in Wisconsin. For improvement in geotechnical properties of soils, a combination of beneficial for lower plasticity and higher silt content soils. The fly ash provides the pozzolanic reactants,

silica and alumina, lacking in such soils. Beeghly [6], [11] carried out the studies by using lime with coal fly ash in stabilization of soil subgrade and granular aggregate base course. Three soil samples of moderate plasticity and high silt content tested for UCS and CBR test. The results show that a lime fly ash mixture can achieve greater strength than lime alone.

II. Materials

A. Soil Sample

The soil sample is collected from Amantpur wadi road, in Aurangabad district of Maharashtra state of India. The soil in this area is clayey (CH) soil. The various properties of soil are tested in the laboratory and results are given in Table I.

B. Pond Ash Sample

After burning of coal in thermal power plant, about 20% to 30% of ash is collected at bottom in the form of slurry. This slurry is deposited in the pond. After evaporation of water from slurry remaining ash in dry form is called as pond ash. For the disposal of this pond ash huge earth surface is required and it also pollutes the ground water. The pond ash sample is collected from the Thermal Power Plant located at Parli, in Beed District of Maharashtra State of India Fig. 1. The basic properties of pond ash are given in Table I.

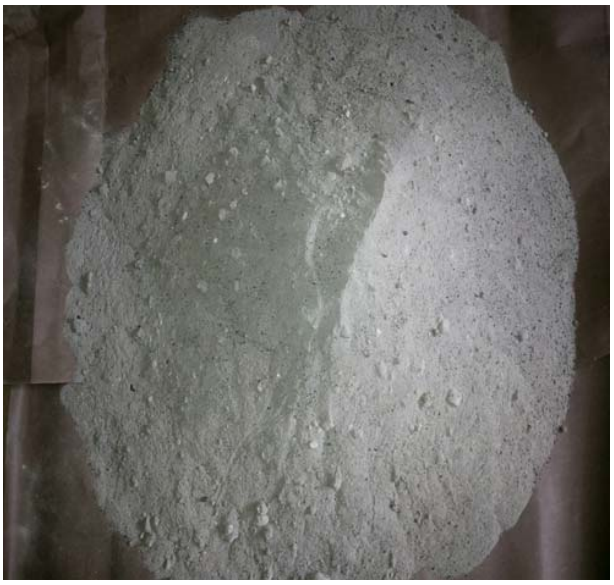

Fig. 1 Pond ash sample

III. Experimentation Work

The standard Proctor test was carried out on the soil sample and different mixes of soil, pond ash and RBI Grade 81 as per Bureau of Indian Standard (IS: 2720- 1980 Part -7) [13]. The CBR test on different soil mixes and grade-III material were carried out in the laboratory as per Bureau of Indian Standard (IS: 2720 Part- 16), [14]. The UCS test was conducted on mixes of soil: pond ash: RBI Grade 81. The free swell test was carried out as per Bureau of Indian Standard (IS: 2911 Part-3) [15] on soil, pond ash and RBI Grade 81 and DFS found out for different mixes.

TABLE I
Basic Properties of CH Soil, Pond Ash, CH Soil + 20% P. A.

Properties	CH soil	P. A	CH soil +20% P.A.
Specific gravity	2.36	2.20	2.30
Liquid limit %	67.00	-	52.47
Plastic limit %	36.46	-	28.63
Plastic index %	30.54	NP	23.84
Maximum Dry density g/cm^3	1.45	1.32	1.47
California bearing ratio %	2.56	1.30	4.56
Optimum moisture content %	28.65	21.32	23.59
Unconfined compressive strength kg/cm^2	2.98	-	1.62
Silt and clay content % (below 0.075)	82.15	21	69.92
Sand content % (0.075 to 4.75 mm)	12.89	79	26.11
Gravel content % (4.75 to 80.0 mm)	4.96	00	3.97
Soil classification	CH	-	-

IV. Results and Discussion

A. Effect of RBI Grade 81 on MDD and OMC of Soil

The results of the MDD and OMC for untreated soil and soil treated with different percentage of RBI Grade 81 are as given in Table II. Fig. 2 shows that, there is increase in MDD of treated soil with RBI Grade 81 than untreated soil. The RBI Grade 81 reacts chemically with soil particles and binds them together and reduces the pore spaces and help to increase the MDD of soil. The RBI Grade 81 contains fibers due to which the increase in MDD is less and if the percentage of RBI Grade 81 increases the MDD of soil reduces.

B. Effect of Pond Ash on MDD and OMC of Soil

The values of MDD and OMC for mix soil: pond ash for different proportions was determined and is as given in Table II. Fig. 3 shows that the MDD of mix of soil and pond ash increased as compared to untreated soil. The increase in MDD of mix soil: pond ash observed up to 20% of pond ash and after that it decreases due reduction in cohesion between soil and pond ash particles. The OMC of mix soil and pond ash also increases as the percentage of pond ash increases due more absorption of water by pond ash.

C. Effect of RBI Grade 81 and Pond Ash on MDD and OMC of Soil

Table II shows the results of MDD and OMC for soil treated with different percentage of pond ash and 2% of RBI Grade81. Fig. 4 shows that, the MDD of treated soil with RBI Grade 81 and pond ash is increases as compared to untreated soil untreated soil. The pond ash and RBI Grade 81 react with soil and binds the soil particles together due to which the MDD of mix increases. As the percentage of pond ash increases the binding of soil particles reduces due which, the MDD of mix decreases.

TABLE II
EFFECT OF POND ASH AND RBI GRADE 81 ON MDD AND OMC OF SOIL

Soil : Pond ash: RBI Grade 81	MDD g/cm^3	OMC in %
100	1.45	25.80
98:02	1.47	26.16
96:04	1.48	26.67
90:10	1.47	22.76
80:20	1.48	24.84
70:30	1.44	26.31
88:10:02	1.49	21.07
78:20:02	1.46	25.76
86:10:04	1.45	25.10
76:20:04	1.44	26.59

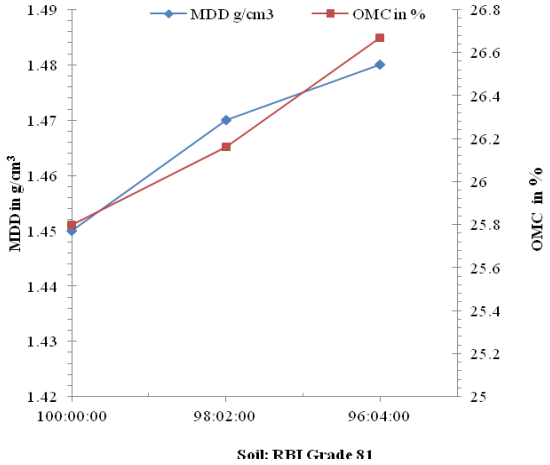

Fig. 2 Effect of RBI Grade 81 on MDD and OMC of soil

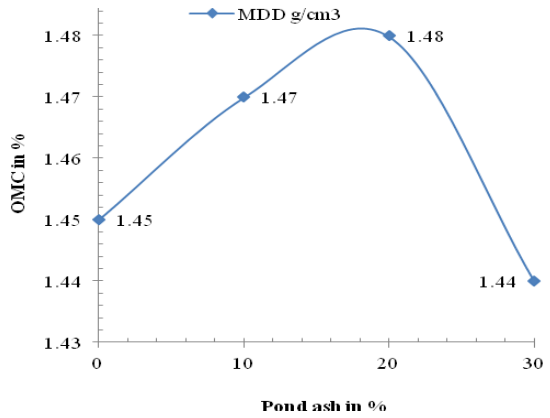

Fig. 3 Effect of pond ash on MDD of soil

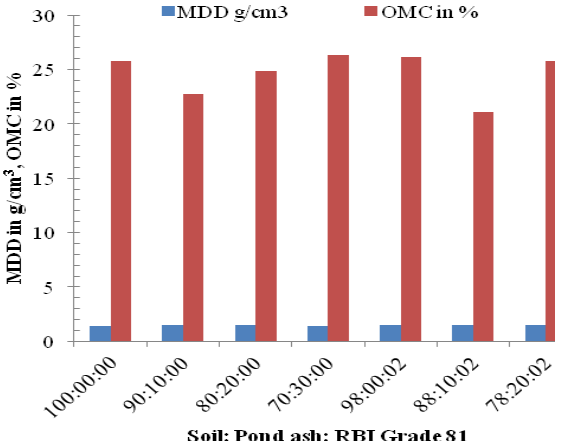

Fig. 4 Effect of pond ash and 2% RBI Grade 81 on MDD and OMC of soil

The OMC of soil treated with 2% RBI Grade 81 and different percentage of pond ash is increases due to chemical reaction between soil, pond ash and RBI Grade 81, also pond ash absorbs more amount of water.

Similarly soil is treated with 4% RBI Grade 81 and different proportions of pond ash and the results are given in Table II. Fig. 5 shows that, the MDD of 4% RBI Grade 81 and pond ash increases for 86:10:04 proportion as compared to untreated soil.

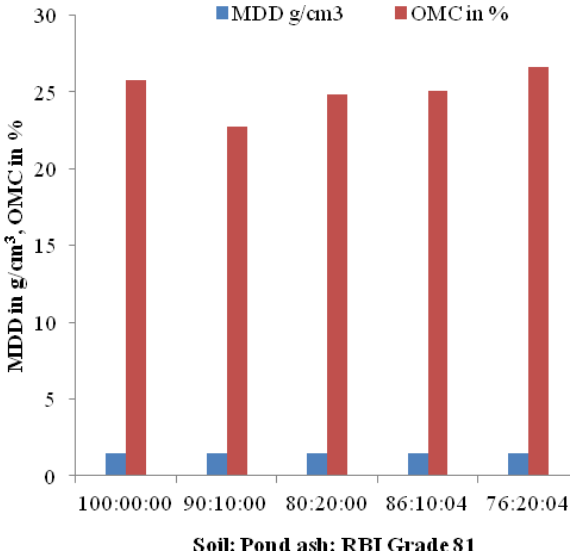

Fig. 5 Effect of pond ash and 4% RBI Grade 81 on MDD and OMC of soil

As the percentage of pond ash increases in the mix, the MDD of soil decreases. The RBI Grade 81 contains fibers due to which for more percentage of it MDD reduces. Also the increase in pond ash percentage MDD reduces. In this case, also OMC of mix increases as the percentage of pond ash increases.

D.Effect of RBI Grade 81 and Pond Ash on DFS of Soil

The clayey soil were tested for DFS for different proportions of soil, pond ash and RBI Grade 81, the results are given in Table III. The clayey soil having maximum differential free swell index due to its mineral constitutes. Fig. 6 shows that DFS of treated soil with pond ash only is decreases as compared to untreated soil. The DFS value reduces considerably due to addition of RBI Grade 81 as compared to untreated soil and soil treated with pond ash. When the RBI Grade 81 and pond ash added for different proportions in the clayey soil, the DFS also decreases. The decrease in DFS indicates the reduction in swelling of clayey soil due to chemical reaction between pond ash and RBI Grade 81 with the clayey soil.

TABLE III
EFFECT OF RBI GRADE 81 AND POND ASH ON DFS OF SOIL

Sr. No.	Soil: Pond ash: RBI Grade 81	Differential free swell index in %
1	100:00:00	60
2	80:20:00	50
3	97:00:03	45
4	96:00:04	40
5	77:20:03	45
6	76:20:04	40

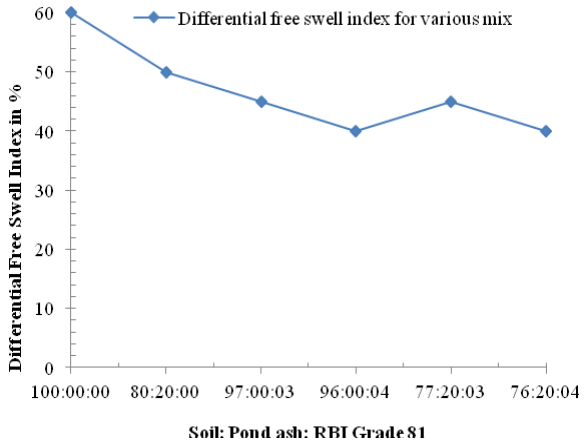

Fig. 6 Effect of RBI Grade 81 and pond ash on DFS of soil

E. Effect of RBI Grade 81 and Pond Ash on Liquid Limit, UCS and CBR Value of Soil

The clayey soil with different proportions of pond ash and RBI Grade 81 were tested for LL, UCS and soaked CBR value, the results are as given in Table IV. The UCS value of treated soil with pond ash reduces as compared to untreated soil due less cohesion of pond ash particles. When the RBI Grade 81 added in soil, the UCS value increases significantly compared to untreated soil. It is also observed that the UCS value of soil, pond ash and RBI Grade 81 increase. Fig. 6 shows that, the LL of treated soil with pond ash decreases as compared to untreated soil. The LL of treated soil with RBI Grade 81 also reduces but the reduction is more as compared to soil treated with pond ash. When the soil treated with RBI Grade 81 and pond ash together, the reduction in LL of soil is maximum.

TABLE IV
EFFECT OF POND ASH AND RBI GRADE 81 ON CBR VALUE OF SOIL

Soil: Pond ash; RBI Grade 81	UCS in kg/cm^2	Liquid limit %	Soaked CBR value in %	% Increase in CBR value
100	4.35	67	2.56	0.00
90:10	0.58	58	3.40	32.81
80:20	1.62	52	4.56	78.12
98: 02	7.24	60	4.89	91.01
88:10:02	1.73	56	4.95	93.34
78:20:02	1.82	46	6.82	166.41
96: 04	8.69	55	8.79	243.36
86:10:04	3.48	50	9.25	261.32
76:20:04	4.73	41	12.74	397.65

This reduction in LL of soil is due to chemical reaction between soil, RBI Grade 81 and pond ash. Fig. 6 shows that as the LL of soil reduces for different proportions of soil, pond ash and RBI Grade 81, there is considerable increase in soaked CBR value of soil. The percentage increase in soaked CBR value of soil as compared to untreated soil is as shown in Fig. 7. It shows that, there is significant increase in soaked CBR value of soil for different proportions of soil, pond ash and RBI Grade 81.

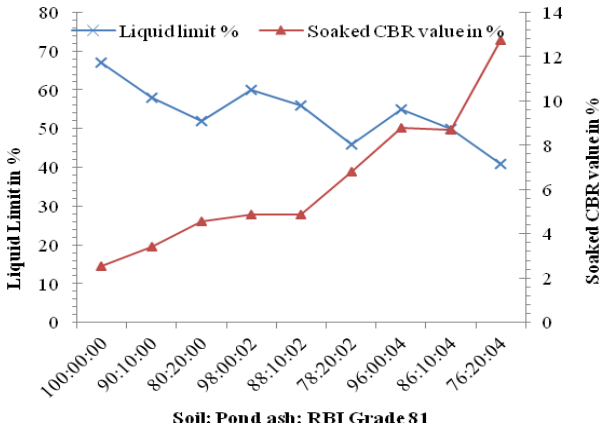

Fig. 7 Effect of RBI Grade 81 and pond ash on LL and CBR value of soil

The soaked CBR value of soil increases due fibers present in RBI Grade 81 and its binding property. The optimum mix obtained from the study is soil: pond ash: RBI Grade 81 for proportion 76:20:04. As the percentage of pond ash increases, the increase in CBR value reduces.

F. Effect of RBI Grade 81 on CBR Value of Grade- III, Base Course Material

The base course grade-III material was taken as per Table 400.1 [16], and tested for soaked CBR value. The grade-III material was mixed with 3% and 4% RBI Grade 81, the CBR test results are as given in Table V. Fig. 8 shows that the soaked CBR value of treated grade-III material with RBI

Grade 81 increases, as compared to untreated grade-III material.

TABLE V
EFFECT OF RBI GRADE 81 ON BASE COURSE GRADE-III MATERIAL

Proportions	Soaked CBR value in %	% increase in CBR value
Untreated Grade - III	34.71	-
Grade – III + 20% Pond ash	42.89	23.57
Grade – III + 20% Pond ash +3% RBI Grade 81	62.75	80.78
Grade – III + 20% Pond ash +4% RBI Grade 81	78.42	125.93
Grade – III + 3% RBI Grade 81	81.32	134.28
Grade – III + 4% RBI Grade 81	93.85	170.38

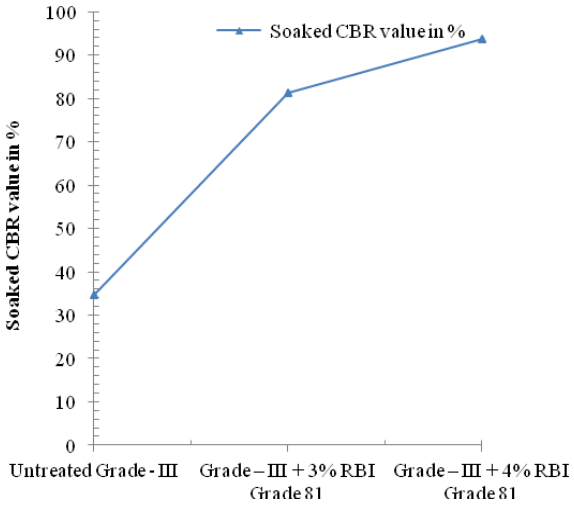

Fig. 8 Effect of RBI Grade 81 on base course grade-III material

TABLE VI
EFFECT OR RBI GRADE 81 AND POND ASH ON GRADE-III MATERIAL

Proportions	% Soaked CBR value
Untreated Grade - III	34.71
Grade – III + 20% Pond ash	42.89
Grade – III + 20% Pond ash + 3% RBI Grade 81	62.75
Grade – III + 20% Pond ash + 4% RBI Grade 81	78.42
Grade – III + 3% RBI Grade 81	81.32
Grade – III + 4% RBI Grade 81	93.85

The soaked CBR value of grade-III material treated with 4% RBI Grade 81 is increased by 170.38%, as compared to untreated grade-III material. The RBI Grade 81 helps to bind the entire grade-III materials together and it helps to increase the CBR value.

G.Effect of RBI Grade 81 and Pond Ash on Grade-III Base Course Material

The base course grade-III material was treated with 20% pond ash 3% and 4% RBI Grade 81; the results are as given in Table VI. Fig. 9 shows the increase in soaked CBR value of grade-III material treated with RBI Grade 81 by 118% as compared to pond ash only. It also shows that the CBR value of grade-III material treated with pond ash and RBI Grade 81 increases significantly as compared to untreated grade-III material. The pond ash and RBI Grade 81 binds the grade-III material and increases the compressive strength.

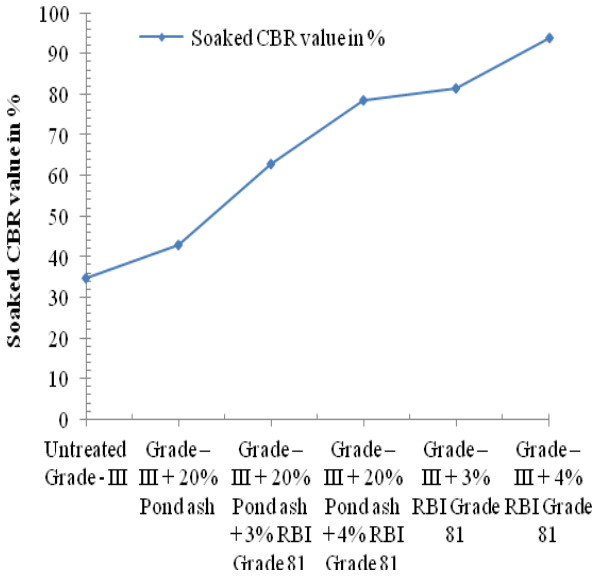

Fig. 9 Effect of RBI Grade 81 and pond ash on grade- III material

V.CONCLUSION

Based on the laboratory experimental investigations in this study following conclusions can be drawn.

i. The geotechnical properties of clayey soil improve significantly due to addition of pond ash and RBI Grade 81.
ii. The RBI Grade 81 and pond ash help to reduce the swelling characteristics of clayey soil as the DFS index reduces.
iii. The RBI Grade 81 work as a good clayey soil stabilizer.
iv. The soaked CBR value of subgrade clayey soil and grade-III material improved by addition of pond ash and RBI Grade 81and therefore it is possible to reduce the thickness of road. The optimum mixed obtained for subgrade soil is 76:20:04 and for base course 77:20:03.
v. The use of locally available clayey soil for subgrade saves natural granular material.
vi. The use of pond ash for road construction work reduces environmental pollution up to certain extent.

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