

# IMPROVEMENT OF SUBGRADE BY RBI GRADE 81 AND POND ASH

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**Abstract** - The present project deals with use of pond ash and RBI Grade 81 for enhancement in CBR values of clayey and silty soil. The tests like Maximum Dry Density (MDD), Optimum Moisture Content (OMC), California bearing ratio (CBR) and Dynamic cone penetration (DCP) tests were conducted on the soil in the laboratory for different percentages of RBI Grade 81 i.e. 2%, 3% & 4% along with 3%, 6% & 9% pond ash. From the test results it has been observed that the engineering properties of clayey and silty soil can be enhanced considerably, if pond ash added with RBI Grade 81. The optimum combination suggested for clayey and silty soil is 3% RBI Grade 81 and 3% pond ash and also very cost effective. It was found that with the addition of Pond ash along with RBI Grade 81, 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.

**Key Words:** Clayey Soil, Silty Soil, RBI Grade 81, Pond Ash, CBR, DCPT.

## 1. INTRODUCTION

In the countries like India the biggest problem in constructing pavement is to constructing pavement is to make local available soil into use, as all the available soil cannot be use for constructing the pavement because of its low engineering properties and strength. Therefore to improve its engineering properties, nowadays these soils is been treated with the stabilizers like lime, Class C Fly Ash, Portland cement, Pond Ash ,RBI Grade 81 etc to improve its engineering property. RBI 81 is a chemical stablizer which is developed for the soil stabilization in a least cost manner and pond ash is thermal power plant waste which has been made into use along with RBI Grade 81 to cut down the cost of construction of pavement and

give pavement a better durability and strength. In this paper both RBI Grade 81 and Pond Ash has been used in different percentage to stabilize silty and clayey soil. The soils were treated in two manners (i) by RBI Grade 81 (ii) by RBI Grade 81 along with pond ash and tests like OMC, MDD, CBR & DCPT were carried out.

## 2. MATERIAL DETAILS

**Soils:** Clayey Soil collected from Mohali Chandigarh & Silty soil was collected from CCET SEC.26 Chandigarh. Tests were carried out to find out the properties of soils and results are given below in table1&2.

### a) Clayey Soil

**Table-1 clayey soil (properties)**

S.No.	Laboratory Tests	Result
1	Liquid Limit	36.15%
2	Plastic Limit	22.2%
3	Plasticity Index	13.95%
4	Optimum moisture content	10.73%
5	Maximum dry density	2.04 gm/cc
6	I.S. Classification	Clay of intermediate

**b) Silty soil**

**Table-2 properties of silty soil**

S.No	Laboratory Tests	Result
1	Liquid Limit	28.25
2	Optimum moisture content	9.29%
3	Maximum dry density	2.03 gm/cc
4	I.S. Classification	Silt of low plasticity(ML)

**Table-4 Chemical Compositions of Pond ash**

Constituent	Pond Ash%
Silica (SiO <sub>2</sub> )	67.40
Alumina (Al <sub>2</sub> O <sub>3</sub> )	19.44
Iron oxide (Fe <sub>2</sub> O <sub>3</sub> )	8.5
Calcium Oxide(CaO)	2.7
Magnesium oxide(MgO)	0.45
Sulphur (SO <sub>3</sub> )	0.30
Loss of Ignition	3.46

**RBI Grade 81:**

RBI Grade 81 was collected from Alchemist touchnology Ltd. The chemical properties of RBI grade 81 are shown in table 3

**Table-3 RBI Grade properties**

Properties	% By Mass
Calcium Oxide (CaO)	52-56
Silicon Dioxide (SiO <sub>2</sub> )	15-19
Sulphur TriOxide (SO <sub>3</sub> )	9-11
Aluminium Oxide (Al <sub>2</sub> O <sub>3</sub> )	5-7
Iron Oxide (Fe <sub>2</sub> O <sub>3</sub> )	0-2
Magnesium Oxide (MgO)	0-1
Fibers(polypropylene)	0-1
Additives	0-4



**Figure1. Pond Ash Sample**

**Pond ash**

In case of thermal power plant after burning of coal close to 20 to 30% of ash is settled at bottom. This ash is disposed of in the form of slurry. After evaporation of moisture the residual ash is called as pond ash.

Sample OF Pond Ash was received from the thermal power plant at Ropar. The chemical composition of Pond Ash shown in table 4

**3. EXPERIMENTAL INVESTIGATION**

The experiment was made to study the outcome of RBI Grade 81 and Pond Ash on the Geotechnical properties of Clayey and Silty Soil. The experiment was divided into two parts (i)Silty and Clayey Soil were treated with RBI Grade 81(ii) Silty and Clayey Soil were treated with both RBI Grade 81 &Pond Ash and test like MDD,OMC,CBR & DCPT were carried out on both the specimens. The Variation of CBR with RBI 81 and Pond Ash of Silty & Clayey soil are shown in table.

**Table 5:** Variation of CBR with RBI Grade 81 and Pond Ash of clayey soil

Sample Number	CBR	DCPT
0% RBI	23.64	23.06
2% RBI	37.83	37.84
3%RBI	49.92	42.26
4%RBI	50.97	45.91
2%RBI & 3% Pond Ash	40.20	40.27
2%RBI & 6% Pond Ash	47.29	40.92
2%RBI & 9% Pond Ash	38.89	39.99
3%RBI & 3% Pond Ash	53.60	51.52
3%RBI & 6% Pond Ash	48.35	44.66
3%RBI & 9% Pond Ash	45.98	37.84
4%RBI & 3% Pond Ash	54.65	45.28
4%RBI & 6% Pond Ash	52.08	45.18
4%RBI & 9% Pond Ash	47.03	44.16

**Table 6:** Variation of CBR with RBI Grade 81 and Pond Ash of Silty soil

Sample Number.	CBR	DCPT
0% RBI	36.26	30.97
2% RBI	56.93	49.77
3%RBI	60.26	56.23
4%RBI	67.97	57.01
2%RBI & 3% Pond Ash	61.83	52.23
2%RBI & 6% Pond Ash	55.70	45.18
2%RBI & 9% Pond Ash	50.27	44.56
3%RBI & 3% Pond Ash	70.42	60.39
3%RBI & 6% Pond Ash	52.20	45.06
3%RBI & 9% Pond Ash	50.10	44.46
4%RBI & 3% Pond Ash	78.48	63.82
4%RBI & 6% Pond Ash	73.22	57.94
4%RBI & 9% Pond Ash	52.02	48.30

#### 4. RESULTS & DISCUSSION

- **Effect of RBI Grade 81 on MDD and OMC of Clayey Soil**

In table7 & figure 2&3, it can be seen that OMC value of soil treated along RBI Grade 81 increases in compare to virgin soil and value of MDD decreases with increase in RBI Grade 81 in soil.

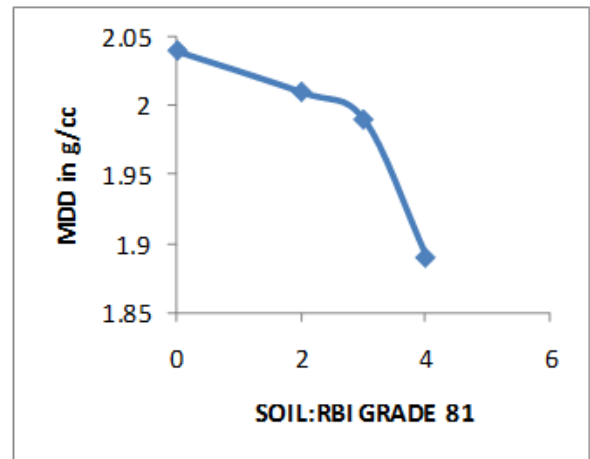
- **Effect of RBI Grade 81 and Pond Ash on MDD and OMC of Clayey Soil**

Table 7& figure 4 shows effect of RBI Grade 81 and Pond Ash on MDD &OMC of soil, as its been observed that MDD

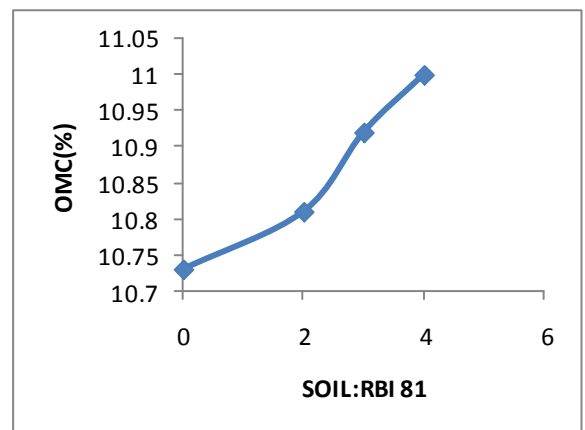
decreases with increase in percentage of pond ash& RBI Grade 81 and OMC increases with increase in percentage of pond ash & RBI Grade 81 as it unite the soil particles jointly which led to increase in OMC mix. . In figure it can be seen that the sample at 2% RBI & 3% pond ash has the maximum MDD value in comparison of untreated soil.

**TABLE 7:** Effect of RBI Grade 81 and Pond Ash on MDD and OMC of Clayey Soil

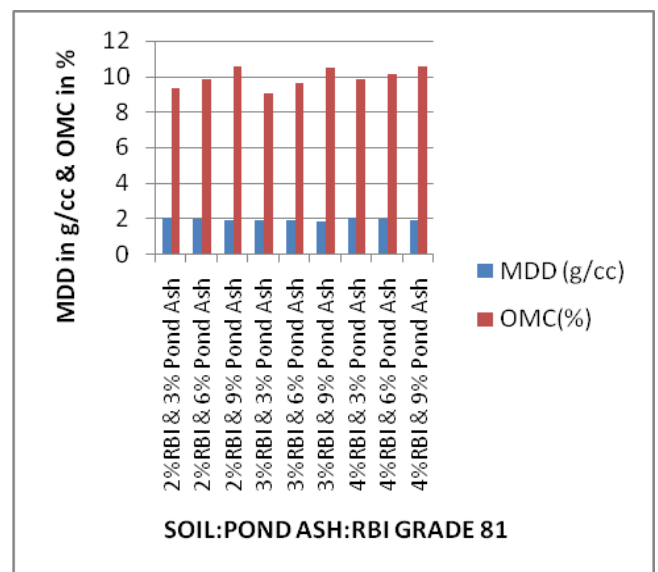
Standard Proctor Test Sample	MDD ( g/cc )	OMC ( % )
0% RBI	2.04	10.73
2% RBI	2.01	10.81
3%RBI	1.99	10.92
4%RBI	1.89	11
2%RBI & 3% Pond Ash	2.08	10.11
2%RBI & 6% Pond Ash	2.05	10.87
2%RBI & 9% Pond Ash	2.04	11.10
3%RBI & 3% Pond Ash	2.02	10.23
3%RBI & 6% Pond Ash	1.99	10.92
3%RBI & 9% Pond Ash	1.91	11.18
4%RBI & 3% Pond Ash	2.00	11.05
4%RBI & 6% Pond Ash	1.97	11.07
4%RBI & 9% Pond Ash	1.94	11.27



**Fig 2 :** Effect of RBI Grade 81 on OMC of Clayey Soil



**Fig-3** Effect of RBI Grade 81 on OMC of Clayey Soil

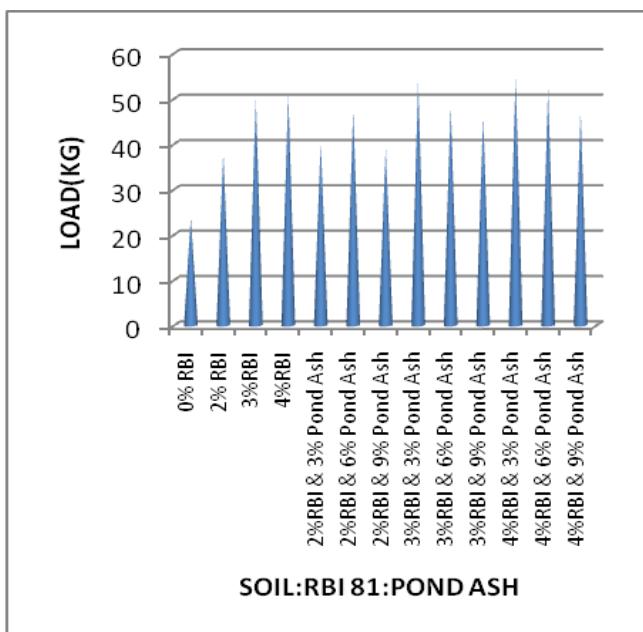


**Fig 4 :** Effect of RBI Grade 81 and Pond Ash on MDD and OMC of Clayey Soil

- **Effect of RBI Grade 81 and Pond Ash on CBR Value of Clayey Soil**

The soil with different percentages of Pond Ash and RBI Grade 81 were tested for CBR, the results are shown in table. The CBR value of un-soaked virgin soil was 23.64% and thereafter mixing 2%, 3% and 4% RBI grade 81, it was found that while the percentage of RBI Grade 81 increases in virgin clayey soil, the CBR value also increases and get dramatically change in percentage variation of CBR as compared to that virgin soil.

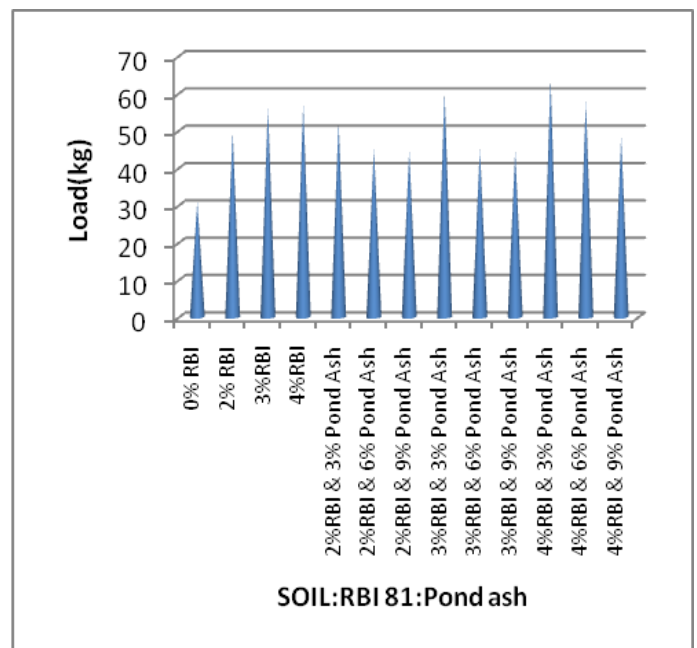
But after treating RBI Grade 81 2%,3% &4% along with pond ash 3%,6%& 9%, its been observed that initial addition of pond ash leads to increase in CBR value. Thereafter it started decreasing with further addition of pond ash. After monitoring all the results the optimum combination which is having the highest Cbr value and all been found very cost effective was 3% RBI Grade 81 and 3% pond ash.



**Fig 5 :** Effect of RBI Grade 81 and Pond Ash on CBR Value of Clayey Soil

- **Effect of RBI Grade 81 and Pond Ash on DCPT Value of Clayey Soil**

The DCPT value of un-soaked virgin clayey soil was 23.06% and thereafter mixing 2%, 3% and 4% RBI grade 81 it was found that with 2% RBI Grade 81, the DCPT value was approximately same as CBR value based on laboratory test and with 3% RBI Grade 81 and 4% RBI Grade 81 DCPT value decreases in respect of CBR value based on laboratory test of 2%, 3% & 4% RBI Grade 81 as shown in table. But after treating RBI Grade 81 2%,3% &4% along with pond ash 3%,6%& 9%, its been observed that value of DCPT is quiet less than the value of CBR based on laboratory test and to improve the value of DCPT more RBI Grade 81 & pond ash is to be added. As it is been observed that the DCPT value is 51.52% at 3% RBI Grade 81 with 3% pond ash and the DCPT value is 45.28% at 4% RBI Grade 81 with 3% pond ash therefore 3% RBI 81 and 3% pond ash is the optimum combination.



**Fig 6** Effect of RBI Grade 81 and Pond Ash on DCPT Value of Clayey Soil

- **Effect of RBI Grade 81 on MDD and OMC of Silty Soil**

In the table & figure it can be seen that OMC value of soil treated with RBI Grade 81 increases in compare to virgin soil and value of MDD of treated soil with RBI Grade 81 increases in respect to virgin soil with increase in RBI 81

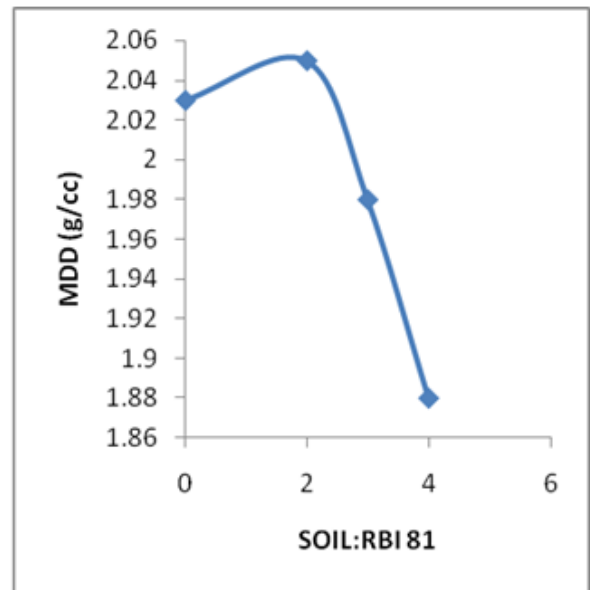
in soil. As the proportion of RBI 81 increases, the value of MDD decreases. The OMC increases and MDD value of soil decreases with increase in RBI Grade 81 in soil.

**• Effect of RBI Grade 81 and Pond Ash on MDD and OMC of Silty Soil**

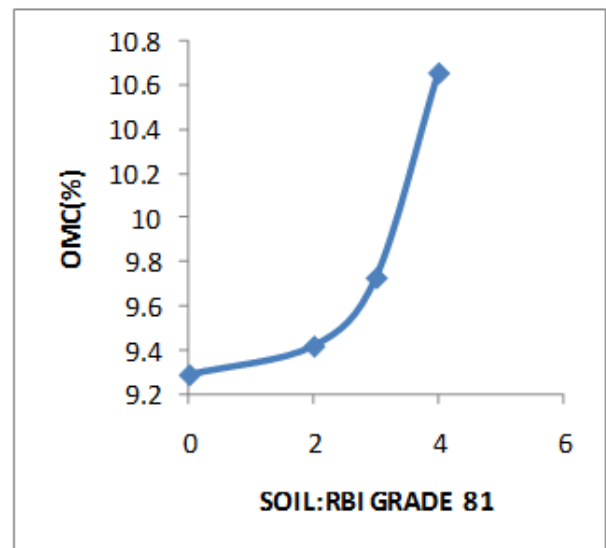
Table 8 & figure 7 & 8 shows the effect of RBI Grade 81 and Pond Ash on MDD & OMC of soil, as it's been observed that MDD decreases with increase in percentage of pond ash & RBI Grade 81 and OMC increases with increase in percentage of pond ash & RBI Grade 81 as it unites the soil particles jointly which led to increase in OMC mix. In figure it can be seen that the sample at 4% RBI & 3% pond ash has the maximum MDD value in comparison of untreated soil.

**TABLE 8:** Effect of RBI Grade 81 and Pond Ash on MDD and OMC of Silty Soil

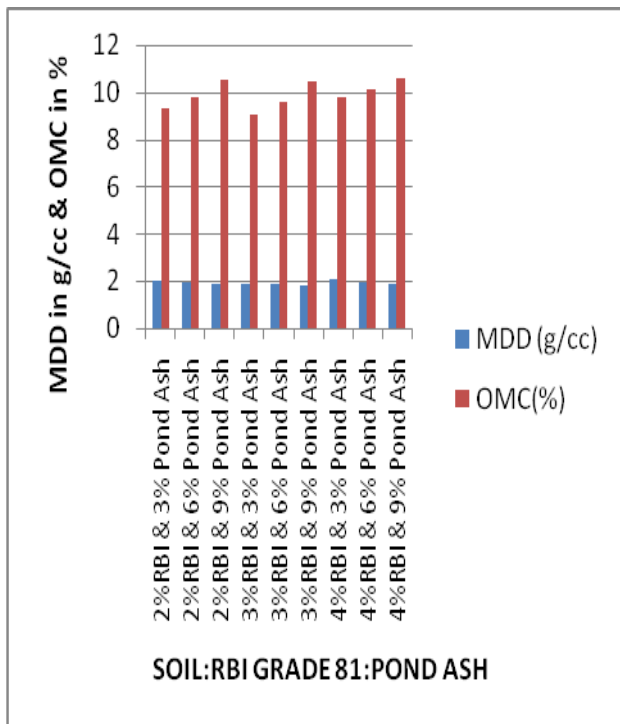
Standard Proctor Test Sample	MDD ( g/cc )	OMC ( % )
0% RBI	2.03	9.29
2% RBI	2.05	9.42
3%RBI	1.98	9.73
4%RBI	1.88	10.66
2%RBI & 3% Pond Ash	1.99	9.32
2%RBI & 6% Pond Ash	1.96	9.81
2%RBI & 9% Pond Ash	1.89	10.53
3%RBI & 3% Pond Ash	1.90	9.03
3%RBI & 6% Pond Ash	1.85	9.59
3%RBI & 9% Pond Ash	1.78	10.48
4%RBI & 3% Pond Ash	2.06	9.82
4%RBI & 6% Pond Ash	1.95	10.13
4%RBI & 9% Pond Ash	1.85	10.57



**Fig 7 :** Effect of RBI Grade 81 on OMC of Silty Soil



**Fig. 8** Effect of RBI Grade 81 on OMC of Silty Soil

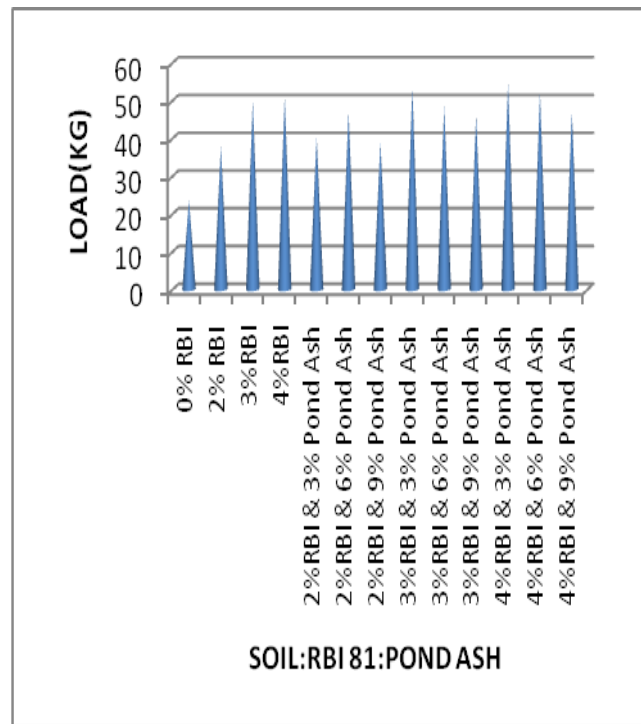


**Fig 9:** Effect of RBI Grade 81 and Pond Ash on MDD and OMC of Silty Soil

**Effect of RBI Grade 81 and Pond Ash on CBR Value of Silty Soil**

The soil with different percentages of Pond Ash and RBI Grade 81 were tested for CBR and results are given in table. The CBR value of un-soaked virgin soil was 36.26 % and thereafter mixing 2%, 3% and 4% RBI grade 81, it was found that as the percentage RBI Grade 81 increases in virgin clayey soil, the CBR value also increases and get dramatically change in percentage variation of CBR as compared to that virgin soil.

But after treating RBI Grade 81 2%, 3% & 4% along with pond ash 3%, 6% & 9%, it's been observed that initial addition with pond ash leads to increase in CBR value. Thereafter it started decreasing with further addition of pond ash. After monitoring all the results the optimum combination which is having the highest CBR value and all been found very cost effective was 3% RBI Grade 81 and 3% pond ash.



**Fig 10:** Effect of RBI Grade 81 and Pond Ash on CBR Value of Soil

**Effect of RBI Grade 81 and Pond Ash on DCPT Value of Silty Soil**

The DCPT value of un-soaked virgin silty soil was 30.97% and thereafter mixing 2%, 3% and 4% RBI grade 81, the DCPT value decreases in respect of CBR value based on laboratory test of 2%, 3% & 4% RBI Grade 81. But after treating RBI Grade 81 2%, 3% & 4% along with pond ash 3%, 6% & 9%, it's been observed that value of DCPT is quite less than the value of CBR based on laboratory test and to improve the value of DCPT more RBI Grade 81 & pond ash is to be added.

As it's seen that the DCPT value was 60.39% at 3% RBI Grade 81 with 3% pond ash and the DCPT value is 63.82% at 4% RBI with 3% pond ash therefore 3% RBI Grade 81 and 3% pond ash is the optimum combination.

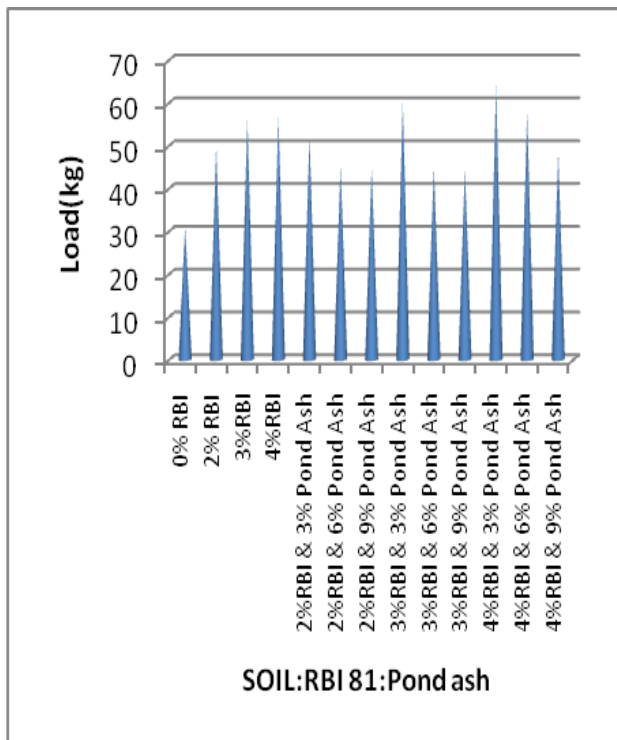


Fig 11: Effect of RBI Grade 81 and Pond Ash on DCPT Value of Soil

4.4.1 Cost and Benefits

Material costs for stabilizers were obtained by contacting suppliers and Alchemist touchnology Ltd. Costs were only obtained for RBI Grade 81 because this is the only stabilizers that produced significant strength improvement for the soils tested. Pond ash has only transportation cost. The estimated costs of material are shown in Table

Table 9 : Estimated Material cost

STABILIZER	COST (RS.)
RBI Grade 81	30 Rupees per kg
Pond Ash	1 Rupees per kg

Table 10: Estimated Cost of 1 cubic meter area for different percentages of RBI Grade 81 & pond ash (clayey soil)

Sample no.	Cost (Rs.)
0% RBI	0
2% RBI	1206
3%RBI	1791
4%RBI	2268
2%RBI & 3% Pond Ash	1310.4
2%RBI & 6% Pond Ash	1353
2%RBI & 9% Pond Ash	1407.6
3%RBI & 3% Pond Ash	1878.6
3%RBI & 6% Pond Ash	1910.4
3%RBI & 9% Pond Ash	1890.9
4%RBI & 3% Pond Ash	2460
4%RBI & 6% Pond Ash	2482
4%RBI & 9% Pond Ash	2502.6

Table 11: Estimated Cost of 1 cubic meter area for different percentages of RBI Grade 81 & pond ash (Silty soil)

Sample no.	Cost (Rs.)
0% RBI	0
2% RBI	1230
3%RBI	1782
4%RBI	2256
2%RBI & 3% Pond Ash	1253.7
2%RBI & 6% Pond Ash	1293.6
2%RBI & 9% Pond Ash	1304.1
3%RBI & 3% Pond Ash	1767
3%RBI & 6% Pond Ash	1776
3%RBI & 9% Pond Ash	1762
4%RBI & 3% Pond Ash	2533.8
4%RBI & 6% Pond Ash	2457
4%RBI & 9% Pond Ash	2386.5



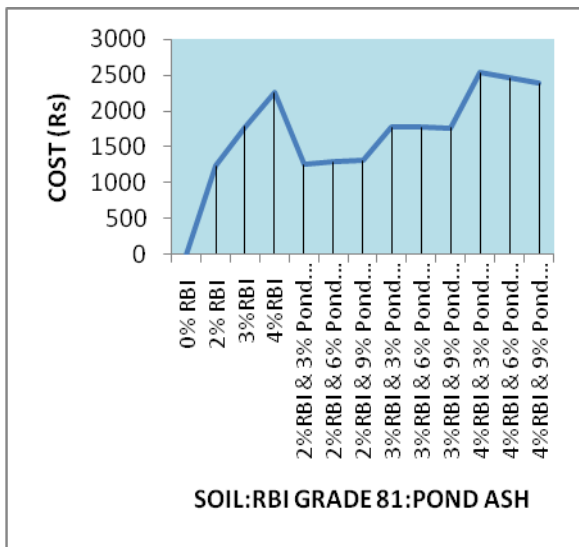


Fig.12 : Estimated Cost of 1 cubic meter area for different percentages of RBI Grade 81 & pond ash (clayey soil)

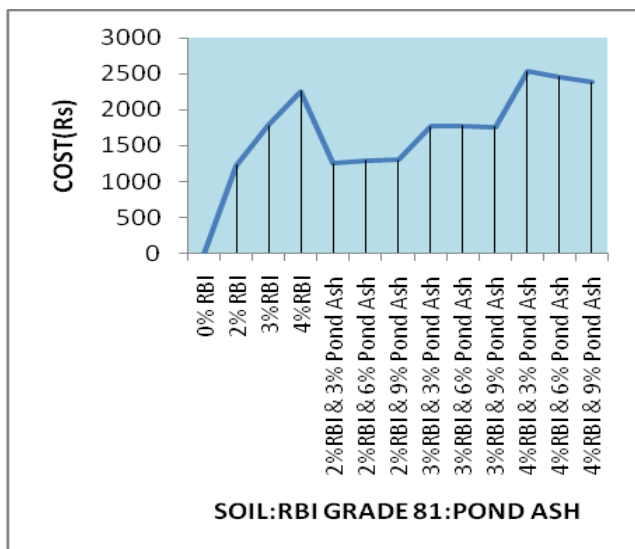


Fig.13 : Estimated Cost of 1 cubic meter area for different percentages of RBI Grade 81 & pond ash (Silty soil)

### 5. CONCLUSIONS

Following Conclusions can be drawn based on laboratory tests.

1. There is increase in OMC and decreased in MDD with addition of RBI 81 but CBR value get increased with

the addition of RBI Grade 81. Therefore the strength will not decrease with decrease in MDD.

- The CBR value of the untreated clayey soil was about 23.64%, which has been increased to 60.02%, 111.16% & 115.60% by adding 2% , 3% & 4% RBI Grade 81. Similarly The CBR value of the untreated silty soil was about 36.26%, which has been increased to 57%, 66.18% & 87.45% by adding 2% ,3% & 4% RBI Grade 81. This shows RBI Grade 81 is extremely good stabilizer
- In case of RBI 81-Pond ash stabilization, the C.B.R. value first increases up to a definite limit and after that the value decreases with more addition of pond ash.
- As the CBR values increases with increase in RBI Grade 81,so it can be recommended for improving the performance of silty and clayey soils.
- The optimum value of RBI Grade 81 is 4% which resulted the CBR value 67.97% and the optimum value of RBI Grade 81 mixed with pond ash is 3% RBI & 3% pond ash which resulted the CBR value 70.42%.By comparing the values it be observed that the 3% RBI & 3% pond ash is giving better result/CBR value than 4% RBI Grade 81.
- Optimum stabilizer percentage for clayey & silty soil is 3% RBI &3% Pond ash. The increase in CBR value of treated silty soil increased by 126.73% in case of 3% RBI and 3% pond ash in respect to virgin soil. The increase in CBR value of treated clayey soil increased by 94.20% in case of 3% RBI and 3% pond ash in respect to untreated soil. From the test results, it can be finalized that pond ash can act as an effective supplement to RBI Grade 81.
- The addition of pond ash showed substantial decrease in MDD and increase in OMC Value both for Clayey & silty soil.
- RBI Grade 81 can be used as a soil stabilizer to reduce the thickness of sub grade for road construction.

9. The use of Pond ash along with RBI Grade 81 considerably improves the geotechnical properties of soil.
10. As the strength of soil increases with an addition of RBI Grade 81, the quality, durability and life period of road will be extra as compare to traditional constructed road.

### ACKNOWLEDGEMENT

The authors can acknowledge any person/authorities in this section. This is not mandatory.

### REFERENCES

- [1]. Anitha.K.R et al.,” Effects of RBI Grade 81 on different types of sub grade soil”, 10<sup>th</sup> National Conference on Technological Trends, Nov 2009.
- [2]. Venu Gopal.N; “Study of Soil Properties With Silica fume As Stabilizer and Comparing the same With Rbi-81 And Cost Estimation” Post Graduate Diploma Thesis, Visvesvaraya Technological University, Belgaum (2009).
- [3]. Sushant Bhuyan, “Stabilization of Blast Furnace Slag and Fly ash using lime and RBI Grade 81” Project Report BE (Civil Engineering) , National Institute of Technology, Rourkela (2010).
- [4]. Satander Kumar, Ex-Scientist CRRI, Consultant, New Delhi Ankul Saxena, Senior Engineer, Alchemist Touchnology, Ltd, New Delhi “Soil and Aggregate Stabilization for Sustainable Pavement” NBMCW December (2010).
- [5]. K.A. Patil et al. “Utilization of Industrial Waste for Soil Stabilization”, Proceedings of International Conference on Advances in Architecture and Civil Engineering (Aarcv 2012, Vol. 1, 21st – 23rd June 2012.
- [6]. K.V. Madurwar et al, “Comparative Study of Black Cotton Soil Stabilization with RBI Grade 81 and Sodium Silicate”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. -2, Issue 2, February 2013.
- [7]. B.M.Patil et al, “Effect of Fly Ash and RBI Grade 81 on Swelling Characteristics of Clayey Soil”, International Journal of Advanced Technology in Civil Engineering, , Vol-2, Issue-2, 2013
- [8]. B.M.Patil, et al “Improvement in properties of Sub grade Soil by Using Moorum and RBI Grade 81”, International Journal of Scientific & Engineering Research, Vol- 4, Issue- 5, May 2013.
- [9]. Tejinder et al, “Strengthening of Sub grade By Using RBI Grade-81”, IOSR Journal of Mechanical and Civil Engineering, Vol - 8, Issue 6, (Sep. - Oct. 2013).
- [10]. B M Patil et al, “Effect of Industrial Waste and Chemical Additives on CBR Value of Clayey Soil”, International Journal of Structural and Civil Engineering Research, , Vol-2, Issue- 4, November 2013.
- [11]. Haricharan T.S et al, “Laboratory Investigation of Expansive Soil Stabilized with Natural Inorganic Stabilizer”, International Journal Of Research In Engineering And Technology,p-ISSN:2321-7308, Nov-2013.
- [12]. B. M. Patil et al., “Effect of Pond Ash And RBI Grade 81 on Properties Of Sub grade Soil And Base Course Of Flexible Pavement”, International Journal of Civil, Architectural, Structural and Construction Engineering, Vol:7,Issue 12, 2013.
- [13]. Mamta et al. “Using RBI Grade 81 a Comparative Study of Black Cotton Soil and Lateritic Soil”, International Journal of Research in Engineering and Technology, eISSN: 2319-1163, Vol- 03, Issue: 03, May-2014.
- [14]. Manisha Gunturi et al, “Effect of RBI-81 on CBR and Swell Behavior of Expansive Soil”, International Journal Of Engineering Research, ISSN: 2319-6890, 2347-5013, Vol-3, Issue.5, pp: 336-339, 01 May 2014.
- [15]. Ahmed. et al, “Effect Of Fly Ash And RBI Grade 81 on Black cotton soil as a sub grade or Flexible

- Pavements”, International Journal Of Innovations In Engineering and Technology, Vol- 4, Issue 1, June 2014.
- [16]. Parijat et al, “Chemical Stabilization of Black Cotton Soil for Sub-Grade Layer”, International Journal of Structural and Civil Engineering Research, Vol.- 3, Issue- 3, August 2014.
- [17]. Lekha B.M et al “Laboratory Performance of RBI 81 Stabilized Soil for pavements”, International Journal of Civil Engineering Research, , Vol-5, Issue 2, pp. 105-110 ,2014.
- [18]. Najia Nouf et al “Effect of RBI 81 on Properties of Black Cotton Soil”, International Journal of Recent Development in Engineering and Technology, (ISSN 2347 - 6435 (Online)), 2014.
- [19]. Venu Gopal.N “Study of Soil Properties With Silica fume As Stabilizer and Comparing the same With Rbi-81 And Cost Estimation” Post Graduate Diploma Thesis, Visvesvaraya Technological University, Belgaum; (2009),
- [20]. Pallavi et al.,” Effect Of Addition Of Lime On The Properties of RBI-81 treated expansive Soil Sub grade”, IOSR Journal Of Mechanical And Civil Engineering (IOSR-JMCE) E-ISSN: 2278-1684,P-ISSN: 2320-334X, Volume 12, Issue 2 Ver. III (Mar - Apr. 2015), PP 01-08.
- [21]. Upma et al., “Effect of Cement Kiln Dust And Chemical Additive on Expansive Soil at Subgrade Level”, International Journal Of Innovative Research In Science, Engineering And Technology, Vol. 4, Issue 5, May 2015
- [22]. B.M.patil et al., “Effect of Fly Ash and RBI Grade 81 on geotechnical properties of sub grade soil”.
- [3]. [www.wisegeek.com/what-are-the-different-types-of-soil-testing.htm](http://www.wisegeek.com/what-are-the-different-types-of-soil-testing.htm)
- [4]. [home.iitk.ac.in/~madhav/expt14.html](http://home.iitk.ac.in/~madhav/expt14.html)
- [5]. [www.highways.gov.sk.ca/240-20/](http://www.highways.gov.sk.ca/240-20/)
- [6]. [en.wikipedia.org/wiki/Fly\\_ash](http://en.wikipedia.org/wiki/Fly_ash)
- [7]. [http://www.ajer.org/papers/v2\(9\)/P029110117.pdf](http://www.ajer.org/papers/v2(9)/P029110117.pdf)

## BIOGRAPHIES



Bibha Mahto receives her B.Tech degree in Civil Engineering from Greater Noida Institute of Technology in 2012. At present she is in final year of her M. Tech program in Construction and technology management from National Institute of technical teacher training and research



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## WEB-SITES REFERENCES:

- [1]. [www.rbigrade81.com](http://www.rbigrade81.com)
- [2]. [www.scribd.com](http://www.scribd.com)