ISSN: 2581-3404 (Online)
International Journal of Innovative Research in Technology and Management (IJIRTM), Volume-3, Issue-3, 2019

# An Experimental Study of Natural Soil Stabilized With Red Mud

**Azhar Afsar Pasha[1], Pratiksha Malviya[2]**
**[1]M.Tech.Scholar, [2]Asst. Professor, Department of Civil Engineering**
**[1,2]Millennium Institute of Technology, Bhopal, India.**

**Abstract-**Soil is very important in civil engineering constructions. The poor engineering properties of the local soils may present many difficulties for construction and therefore need to improve their engineering properties. Stabilization techniques can be used to improve the properties of soil. Soil stabilization improves various engineering properties e.g. bearing capacity, compressibility, strength, and various other properties of soil. In this study the impact of Red Mud to improve the strength of soil. The soil was stabilized with Red Mud in stepped concentration of 4%, 8%, 12%, 16%, 20% and 24% by dry weight of the soil individually. All stabilized soil samples were also cured for 96 hours for CBR test in fully saturated condition. The test results indicate that the addition of Red Mud enhances the percentage of grain size distribution, but with addition of Red Mud till 16% the LL, PL, PI and decreases, while these parameters further increases in this limit beyond i.e. 16% to 24% of Red Mud.

**Keywords:-** OMC, MDD, Un-Soaked CBR, Soaked CBR, Natural Soil.

## INTRODUCTION

Soil is the basic construction material. It supports the substructure of any structure and in case of pavement structures; sub-grade soil is an essential component as it supports the sub-base/base. However, in many situations, soils in natural state may not possess adequate geotechnical properties so as to be used as foundation layers, pavement layer or as a construction material. This may be due to the fact that the existing soil at a particular location exhibits poor bearing capacity and higher compressibility. Also, soils with significant plasticity may shrink and swell substantially with changes in moisture conditions. The repeated cycles of swelling or shrinkage of soil, further cause deteriorations and distresses on the structures if these are supported in these types of soil, This necessitates the improvement/stabilization of soil at a site as an indispensable activity, due to rising cost of the land and a huge demand for infrastructure development in developing countries like India. Soil stabilization is a technique introduced with the main purpose to modify the geotechnical properties of the soils making them capable of meeting the requirements of the specific engineering projects.

The most common improvements achieved through stabilization include better soil gradation reduction of plasticity index or swelling potential and increases strength and durability. Various stabilizers such as lime, cement and calcium chloride are traditionally used for the stabilization of expansive soils However, the over dependency on the utilization of such industrially manufactured soil stabilizing additives may significantly increase the cost of construction.

## II LITERATURE REVIEW

This chapter discusses about the different investigation for characteristics of red mud as construction material, stabilization of red mud in different applications in general. **Nawabsharif Risaldar et al. (2017)** Investigation on the properties of black cotton soil, it is observed that, its strength properties are very low. In order to construct any foundation one such soil, we need to stabilize the black cotton soil. Red mud is material produced by aluminum industries, which, now a days creating so many problems when we dump it on open space. To beat both the criteria red mud is used as a stabilizer. Number of mixes is proposed here and experiments are done on the same. Black cotton soil was stabilized with red mud by varying the % of mix from 15% to 30% with 1% interval Gypsum is also used in the mixes in order to give better binding between the particles. It is observed that results obtained at the mix proportions 0% to 25% is increasing. Optimum of 25% of red mud replacement gives better results. After obtaining the test results as stated above, another attempt has been made to understand the interrelation (linear) between the parameters; regression analysis is made. This regression analysis is made using Microsoft Excel 2010; regression summary output is also discussed in this study. **Nitin Mane, et al. (2017)** In particularly, construction activities on black cotton soil brings challenging tasks to him to handle. When the civil structures are needed to construct over the soils, which are unable to provide the desired properties to civil structures for the construction in such cases stabilization is the only method to get the desired properties of soil. By studying the properties of black cotton soil, it is observed that, its strength properties such as UCS and CBR are very low. In order to construct any foundation on the same soil, we need to stabilize the black cotton soil. Black cotton soil was stabilized with red mud by varying the % of mix from 10% to 40% with 2% interval sodium silicate is also used in the mixes in order to give better binding between the particles. It is observed that results obtained at the mix proportions 10% to 30% is increasing. Optimum of 30% of red mud replacement gives better results. Along with this 6% of sodium silicate replacement gives better results. The sodium silicate content increased CBR values got increased up to 8% of sodium silicate. Later as the percentage of sodium silicate increased, CBR values got decreased. The maximum value of CBR being 3.9 %, which is obtained for D308 combination

## III MATERIALS USED

**Soil-** Soil is a collection of earth material, obtained naturally from the decay of vegetation and rocks that may be excavated instantly with help of power equipment in field or disintegrated by gentle mechanical means in laboratory. Supporting soil underneath pavement and its unique under courses is termed as subgrade. Undisturbed soil beneath pavement is termed as natural subgrade. Compacted subgrade is soil compacted with help of controlled movement through heavy compactors. The soil used for this investigation is an expansive clay ,one type of most problematic soil for sub grade constructions is used for current research work which is locally available **Natural** Soil collected Bhopal (Madhya Pradesh) from depth of 2.5 m from ground level. It contains deleterious substances and of various sizes. The soil was air dried and pulverized manually. This natural soil is grey and black in colour.

**Image 1: Natural Soil Sample**

**Red mud-** Red mud (RM) was collected from Bharat Aluminum Company Limited (BALCO), district Korba (C.G). About 1.5 tons of red mud is coming out per ton of alumina produced from the above plant and is discharged in a slurry form to red mud pond, which is about 212 hectares. The slurry has a composition of 45% liquid and 55% solids. Output of red mud is 200t/hour (solids). There is about 20 million tons of waste products accumulated. Fig shows the discharge of red mud as slurry to the red mud pond and the lake view at BALCO, district Korba. Figure 3.2 and 3.3 shows the discharge of red mud as slurry to the red mud pond and red mud pond at BALCO, district Korba. Figure 3.4 shows red mud used in present experimental work

**Size Analysis**-Grain size analysis on natural soil and soil-additive mixture were conducted according to I.S. 2720 (Part IV):1975.

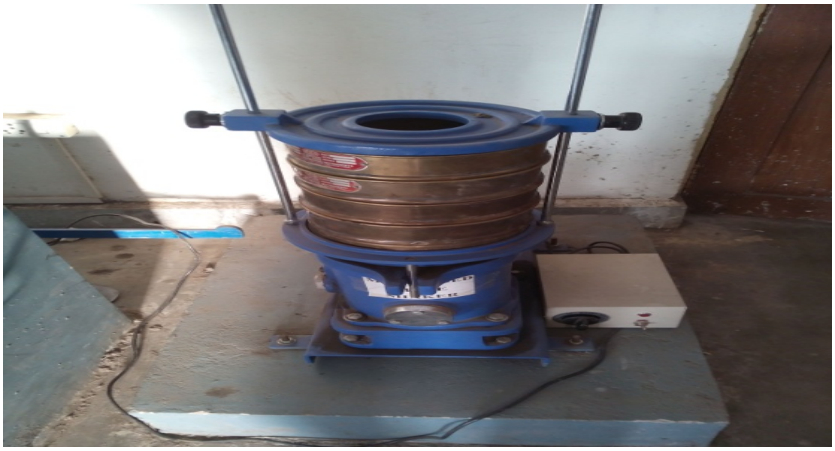


**Image 2: Sieve Analysis Apparatus (Motorised Sieve Shaker)**

**Specific Gravity-** Specific gravity which is measure of heaviness of soil particles are determined by method of pychnometer method using a soil sample passing No. 10 sieve and oven dried at 105 degree centigrade. The test includes determination of specific gravity for natural soil and soil-red mud mixture. Test is executed in accordance with AASHTO T100-93 testing procedure

**Image 3: Specific Gravity test Apparatus (pychnometer)**

**Liquid limit (LL)** - Liquid limit of fine grained soil is defined as water content at which soil behaves practically like liquid but has small shear strength. It is determined in laboratory by Cassagrande apparatus.

**Image 4 : Liquid Limit, Plastic Limit Apparatus**

**Plastic limit (PL)**-Plastic limit of a fine grained soil is water content of soil below which it ceases to be plastic. It begins to crumble when rolled into threads of 3mm diameter. Or the minimum water content at which a soil will just begin to crumble when it is rolled into a thread of approximately 3 mm in diameter.

**Compaction test-** Compaction tests to obtain moisture-density relationship of soil-additive mixtures were conducted according to I.S. 2720 (Part viii)-1965 (11). Compaction is process of soil densification with help of reduction of air voids. Degree of compaction for given soil is calculated in terms of its dry density. The dry density is maximum at optimal water content.

**Image 5: Rammer Apparatus and Sample Prepare for Compaction Test**

**California Bearing Ratio (CBR)-** In 1928, California division of highways in U.S.A. developed CBR method for pavement design. The majority of curves developed later are based on original curves proposed by O. J. porter. At the start of Second World War, Corps Engineer of U.S.A. made survey of existing method of pavement design and adopted CBR method to design military airport pavements. One of the chief advantages of C.B.R method is the simplicity of the test procedure. The CBR tests were executed according to I.S. 2720 (Part xi) 1977. A standard CBR mould with a detachable collar was used.

**Image 6: Test Samples for Soaked and unsoaked CBR**

## IV RESULTS AND DISCUSSION

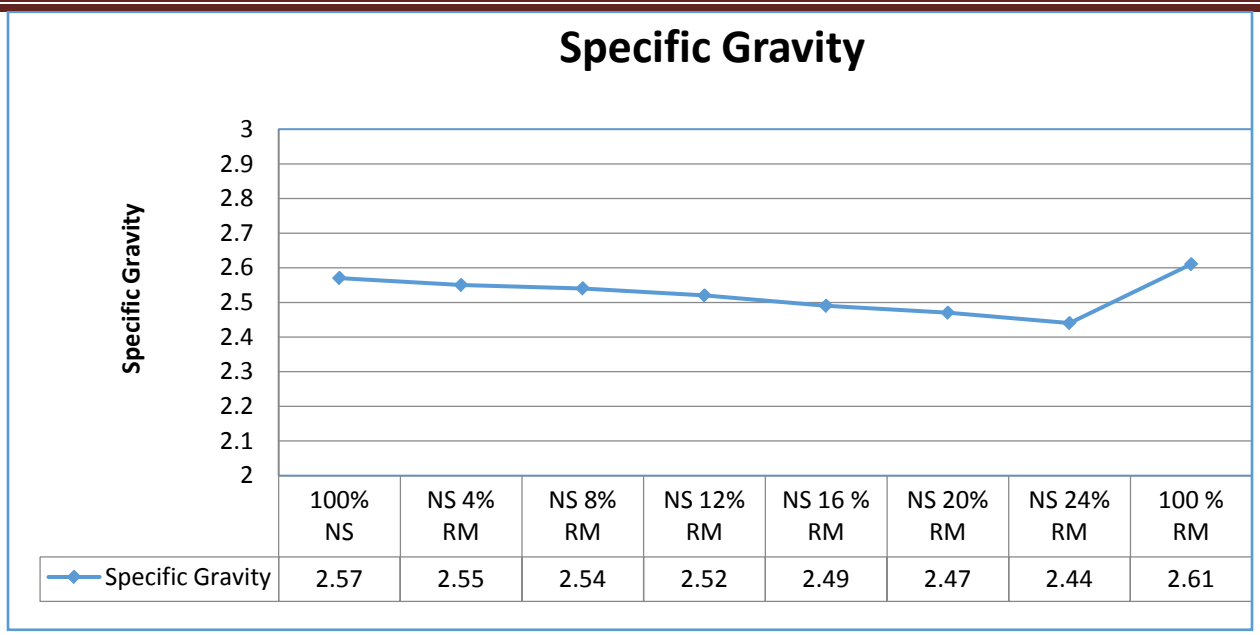
In the present study, Grain Size Analysis, Specific Gravity Test, Consistency Indices (Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI)), Compaction Test, and California Bearing Ratio (CBR) Unsoaked and Soaked Tests were executed on Natural Soil (B.C Soil) first by mixing with altered percentage of Red Mud to stabilize Natural soil and then altered percent of Red Mud at which maximum CBR is gained is chosen for further experimental work.

**Table 4.1: Properties and Classification of Natural Soil**

| | |
|---|---|
| **Specific Gravity** | **2.57** |
| **Gravel (%)** | **21.70** |
| **Coarse Sand (%)** | **8.50** |
| **Medium Sand (%)** | **45.00** |
| **Fine Sand (%)** | **22.80** |
| **Silt and Clay (%)** | **1.80** |
| **Natural Moisture Content (%)** | **41.00** |
| **Liquid Limit (%)** | **37.00** |
| **Plastic Limit (%)** | **26.40** |
| **Plasticity Index (%)** | **10.60** |
| **O.M.C. (%)** | **13.65** |
| **Maximum Dry Density ($gm/cm^3$)** | **1.85** |
| **CBR (%)** | **2.53 (Soaked)** |
| **IS Classification** | **MH** |

### Specific Gravity Test

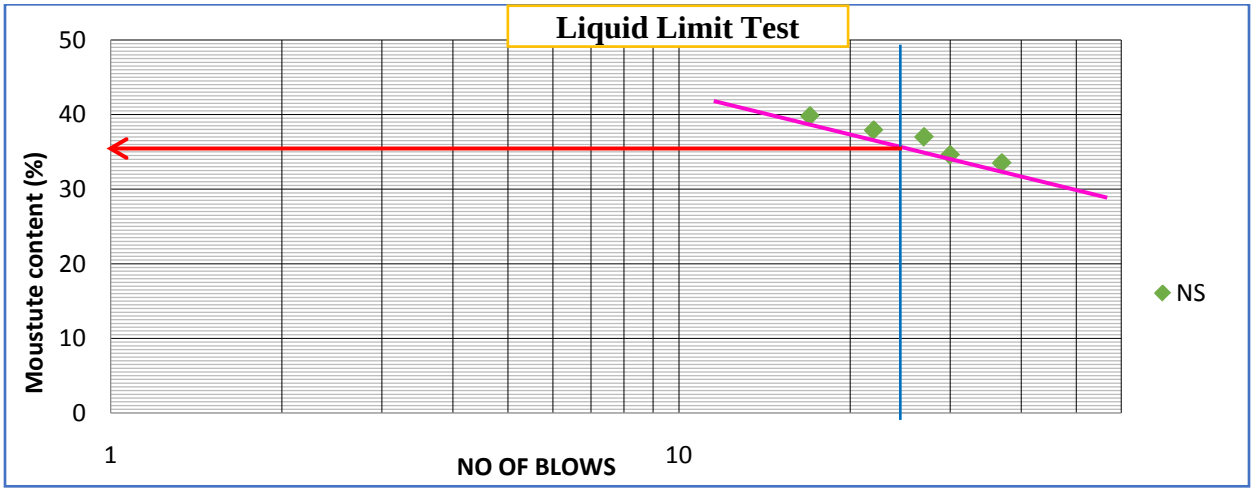
Specific gravity tests were executed to determine specific gravity of raw Natural Soil and Natural Soil with altered percentage of Red Mud. Results are presented in Table- 4.4 from table, it is well recognized that specific gravity value of Natural Soil is 2.57, but as percentage of Red Mud is increases, specific gravity value decreases gradually. It shows that there is a decrease in specific gravity from **2.57 to 2.44** with increase in percentage of Red Mud from 0 to 24% and **2.61** for 100% Red Mud as Show in Table



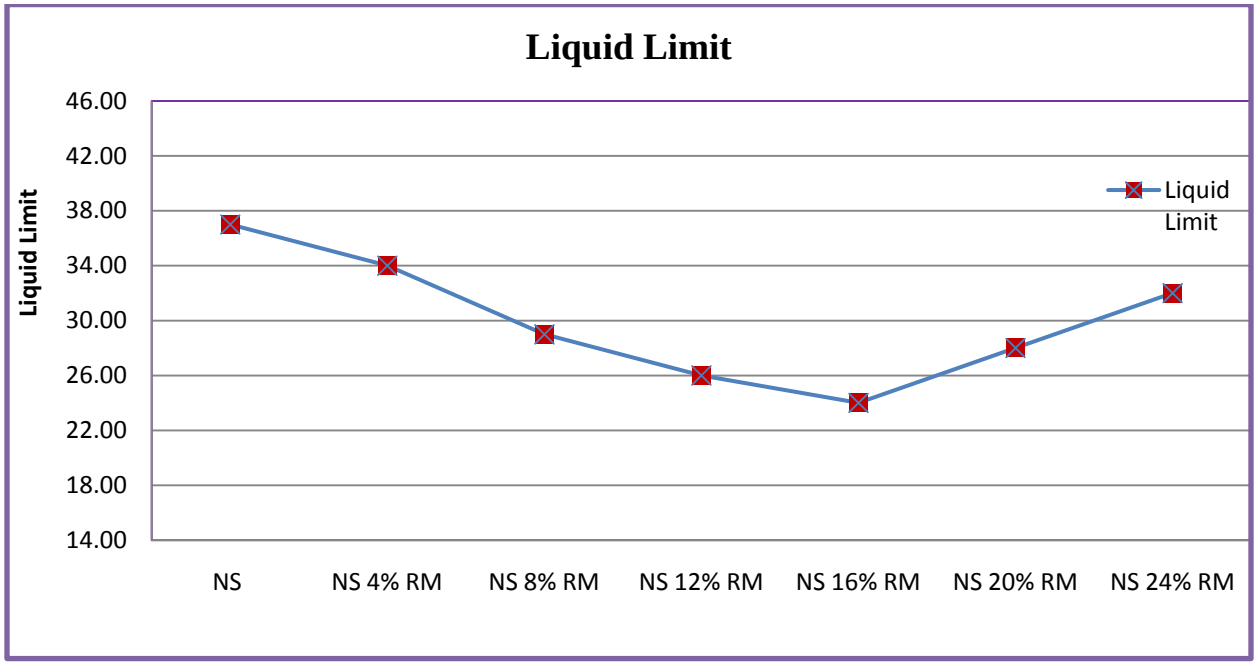

Graph **1-Variation in Specific Gravity of Natural Soil and NS with altered percentages Red Mud**

**Consistency Indices**

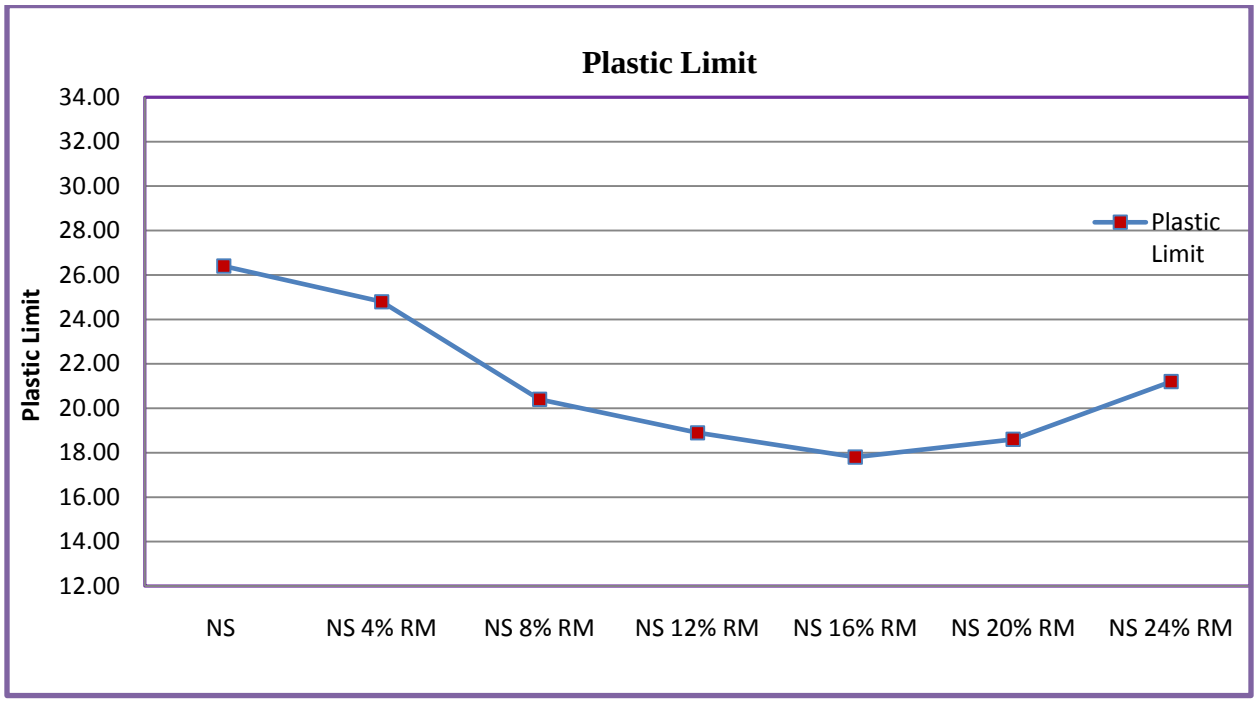
Consistency tests were executed to determine Liquid Limit (LL), Plastic Limit (PL) and then Plasticity Index (PI) of raw Natural Soil and Natural Soil treated with altered percentage of Red Mud. The Liquid Limit, Plastic Limit and Plasticity Index are shown in Table- 4.5. Initially the LL, PL and PI of Natural Soil are **37.00 %, 26.40 %** and **10.60** respectively. Which is very high and soil having these properties cannot be utilized for highway construction especially in sub-grade



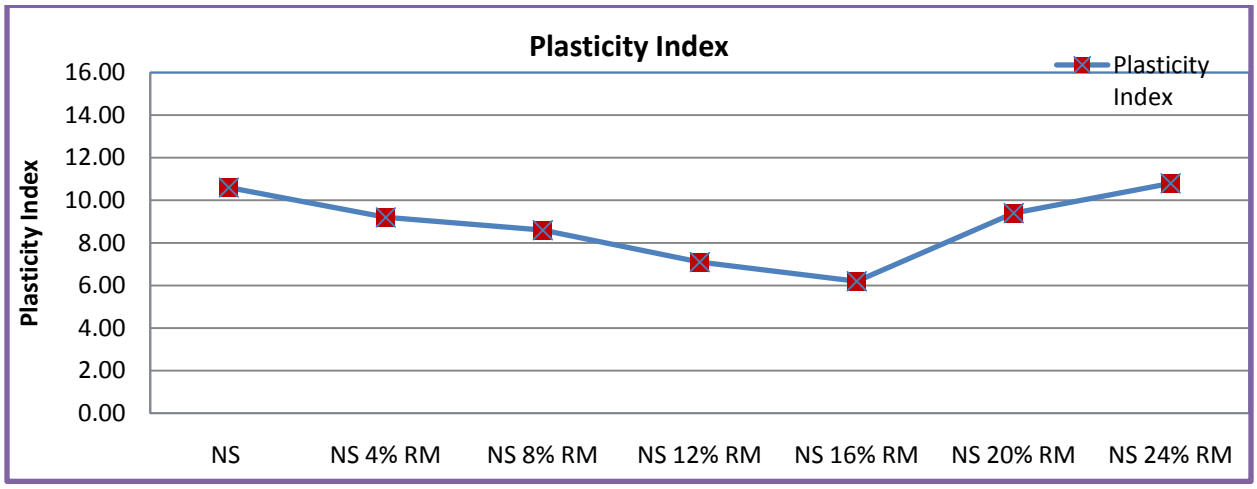

**Graph 2 Liquid Limit Graph for Natural Soil**




**Graph 3 Variation in Liquid Limit with Natural and NS with altered percentages Red Mud**



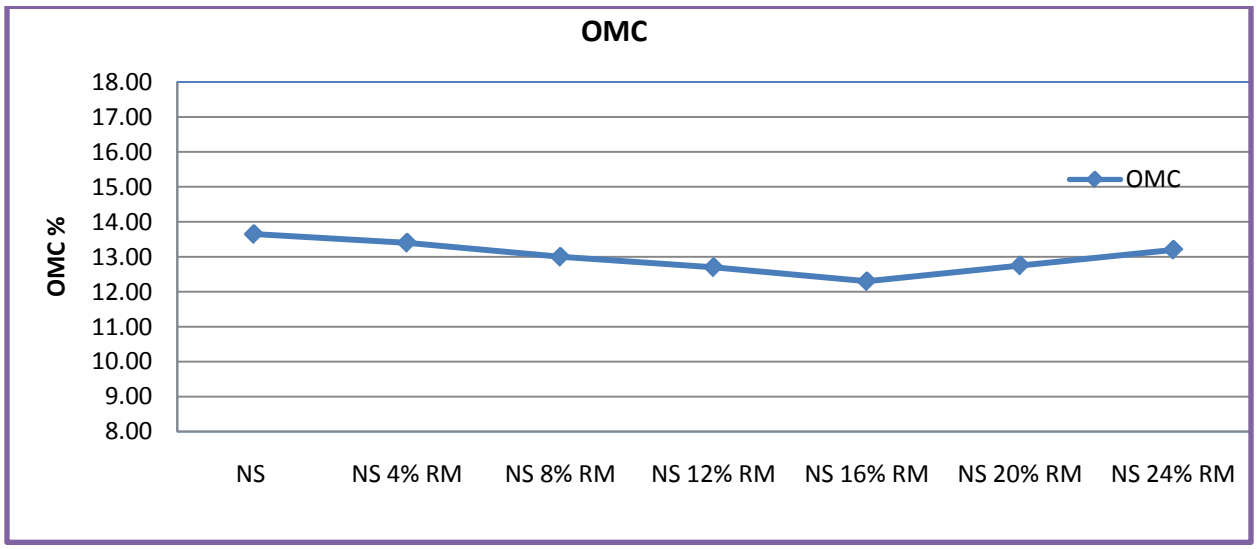

**Graph 4 Variation in Plastic Limit with Natural and NS with altered percentages Red Mud**



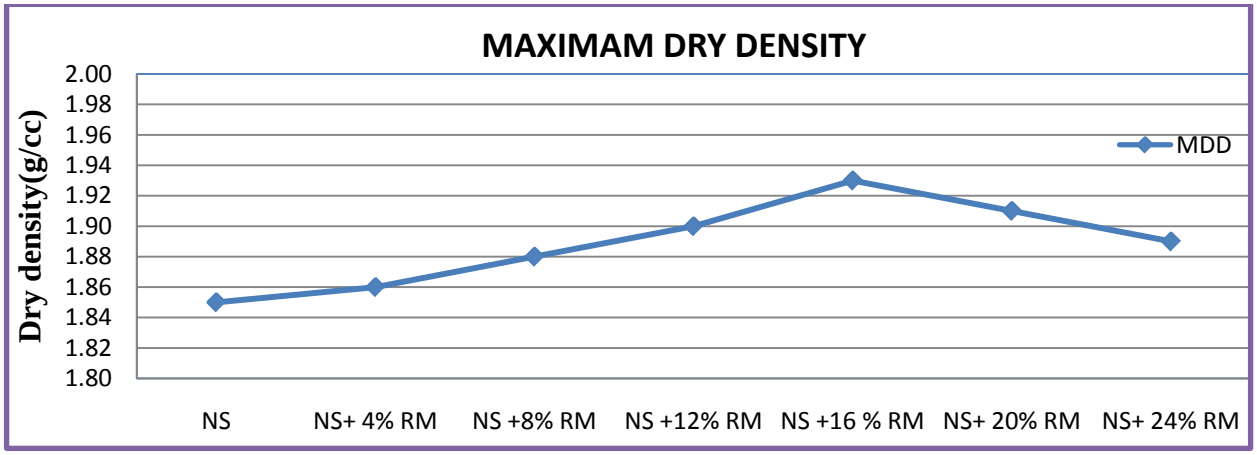

**Graph 5 Variation in Plasticity Index with Natural Soil Natural and Percentages Red Mud**

**Compaction Test**

IS light compaction tests were carried out to determine the Maximum Dry Density (MDD) and optimum moisture content (OMC) for sub-grade soil and for the soil stabilized with varying percentages of Red Mud, The maximum dry density and optimum moisture content for Natural Soil, Natural Soil mixed with varying percentages of Red Mud ranges from 4 percent to 324 percent.



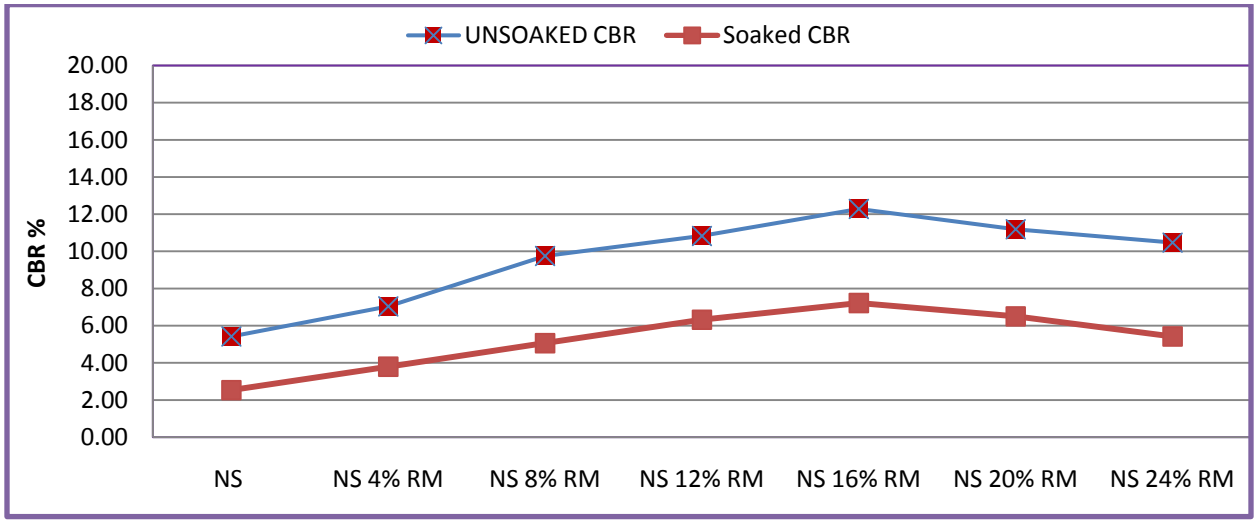

**Graph 6 Variation in OMC with Natural Soil and Natural and NS with altered percentages Red Mud**



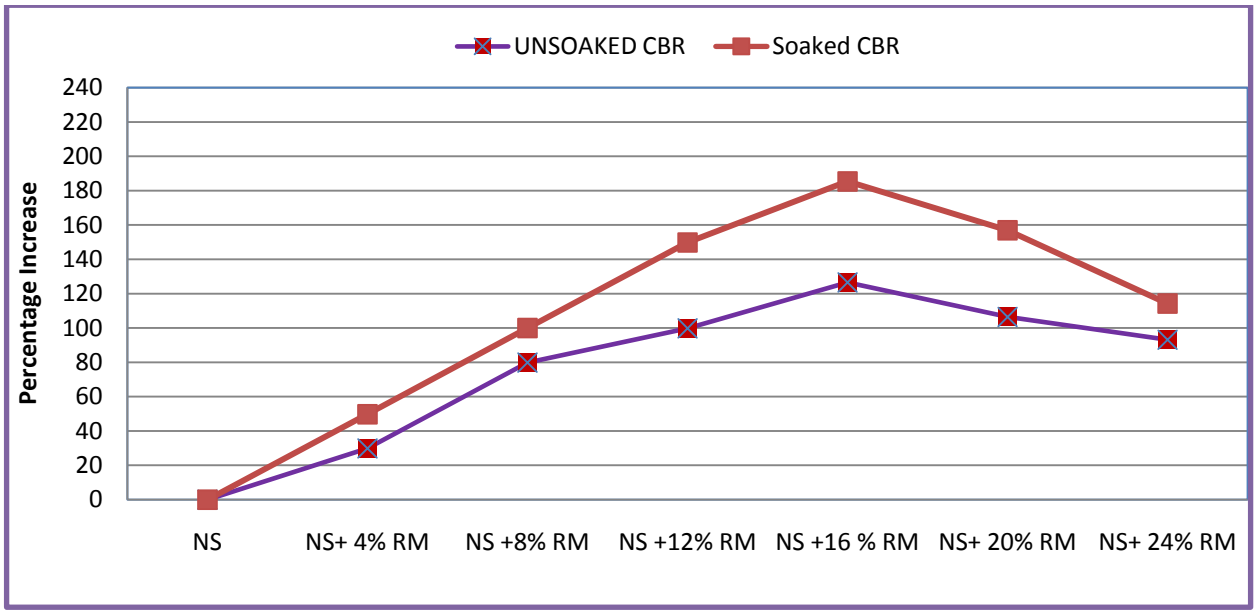

**Graph 7 Variation in MDD with Natural Soil and Natural and NS with altered percentages Red Mud**

**California Bearing Ratio(CBR Test)**

California Bearing Ratio (CBR) tests were executed out to determine CBR Value for sub-grade soil and for soil that may be stabilized with altered percentages of Red Mud, California Bearing Ratio (CBR) Unsoaked and Soaked tests were executed on Natural Soil (B.C Soil) first by mixing with altered percentage of Red Mud to stabilize Natural soil and then altered percent of Red Mud at which maximum CBR is gained is chosen for further experimental work.




**4 Graph 8 Variation in CBR Value of Natural Soil and Natural soil + varying %age of Red Mud**




**Graph 9 Variation of Increase in CBR value of altered % age of Red Mud towards Natural Soil**

## V CONCLUSIONS

As per investigational analysis following conclusions can be drawn.

1. The consistency indices value of the Natural soil reduces with mixing of Red Mud.
2. Initially the LL, PL and PI values of raw soil are 37.00 %, 26.40 % and 10.60 % respectively which on mixing Red Mud in ranges from 4 % to 24 % gradually decreasing in liquid limit from **37 to 24%,** Plastic Limit from **26.60% to 17.80%** and Plasticity Index from **10.60% to 6.20%** when Red Mud is increased from 0 to 16% is effective beyond also there is a increase in liquid limit from **24% to 32%,** Plastic Limit from **17.80 to 21.20%** and Plasticity Index from **6.20 to 10.80%** when Red Mud is increased from 16 to 24%
3. Specific gravity value of Natural Soil is **2.57**, but as percentage of Red Mud is increases, specific gravity value decreases gradually from **2.57 to 2.44** with increase in percentage of Red Mud from 0 to 24%.
4. In Compaction Test, the MDD value of raw soil is achieved as **1.85 gm/cc** at OMC of **13.65%**. It got increased to **1.93 gm/cc** at OMC of **12.30 %** when Red Mud is increased from 0 to 24% is effective beyond also there is decreasing in MDD from **1.93 gm/cc** at OMC of **12.30% to 1.89 gm/cc** at OMC of

**13.20%** when Red Mud is increased from 16 to 24%

5. The Unsoaked CBR value of the raw soil is **5.42 %** and after mixing of Red Mud in the soil, there is remarkable change in CBR value from **5.42 to 12.28%**. when Red Mud is increased from 0 to 16% is effective beyond also there is a decrease in CBR of soil from **12.28 to 10.47%** when Red Mud is increased from 16% to 24%
6. The soaked CBR value of the raw soil is 2.53 % and after mixing of Red Mud in the soil, there is remarkable change in CBR value. increasing from **2.53 to 7.22%** when Red is increased from 0 to 16% is effective beyond also there is a decrease in CBR of soil from **7.22 to 5.42%** when Red Mud is increased from 16% to 24%
7. The results of percentage increment in Unsoaked CBR goes on increasing from **29.89 to 126.57%** with respect to Natural Soil when Red Mud is increased from 0 to 16% and is decreases from **126.57 to 93.17%** when Red Mud is increased from 16% to 24%**.** However in Soaked CBR it increases from **49.80 to 185.38%** when Red Mud is increased from 0 to 24% and is decreases from **185.38 to 114.23%** when Red Mud is increased from 16% to 24%.

**REFERENCES** :-

1. Arora K. R, “Soil mechanics and Foundation Engineering”. Indian Road Congress (IRC-37-2012).
2. IS: 2720 (Part III )
3. IS: 2720 (Part V)
4. IS: 2720 (Part VII)
5. IS: 2720 (Part XL)
6. IS: 2720 (Part XVI)
7. Kalkan (November 2006) Utilization of red mud as an adjustment material for the planning of mud liners 87(3):220-229.
8. Desai, M. V. G., Herkel, R. N., (2010). Red Mud Bricks – An elective Low Cost Building Material. sixth International Congress on Environmental Geotechnics, New Delhi, India.
9. Basta, N. Ribeiro, D. V., Labrincha, J. An., and Morelli, M. R. (2011). Potential utilization of common red mud as pozzolan for Portland bond. Materials Research, 14(1), 60– 66.
10. Khan, J., Amritphale, S. S., Chandra, N., and Patel, M. (2012). A novel folio free and energyefficient process for making fired tiles utilizing red mud and sericitic pyrophyllite. Indian Journal of Chemical Technology, 19(6), 420– 426.
11. Rebata-Landa, V., and Santamarina, J. C. (2012). Mechanical Effects of Biogenic Nitrogen Gas Bubbles in Soils. Diary of Geotechnical and Geoenvironmental Engineering, 138(2), 128– 137.
12. Wang, P., and Liu, D. Y. (2012). Physical and Chemical Properties of Sintering Red Mud and Bayer Red Mud and the Implications for Beneficial Utilization. Materials, 5(10), 1800
13. Defeat S., Sahoo T. what's more, Das S.K. (2012). Utility of Red Mud as an Embankment Material. Bury National Journal of Earth Sciences and Engineering. ISSN 0974-5904, Volume 05,No.06, 1645-1651.

**14.** Rathod, R., Suryawanshi, N., and Memade, P. (2013). Assessment of the properties of Red Mud Concrete. Procedures of the Second International Conference on Emerging Trends in Engineering 2013 IOSR Journals, 31– 34.

**15.** Satyanarayana, P. P. V. V, Harshitha, An., and Priyanka, S. (2013). Usage of Red Soil Bentonite Mixes as Clay Liner Materials, 4(5), 876– 882.
ology,. IJAET ISSN: 22311963