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STABILIZATION OF LATERITE SOIL USING RED MUD FOR PAVEMENT CONSTRUCTION:A REVIEW

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Abstract – Red mud is highly alkaline slurry produced during alumina extraction from bauxite. Its disposal generates serious environmental pollution. The best way to solve red mud disposal issues is Red to develop economic utilization technologies that consume significant amounts of red mud. This paper reviews the possibility of utilizing red mud as a road base material, weak subgrade soil stabilizer as well as a subgrade material. Results showed that red mud can be used for those purposes. It was also found that the stabilizing content needed to meet a certain standard differs due to differences in requirements from one country to another. Therefore, there is a need to design proportions with UCS, CBR, leaching characteristics required by the country in which red mud is intended for use. The effect of various stabilizers on performance of red mud is discussed and it transpired that lime showed the best performance followed by dolime fine, ground granulated blast furnace slag, cement kiln dust and fly ash. Findings indicated that red mud shows better performance as a subgrade material than natural soil. Also the synergistic use of red mud and other wastes also improves the mechanical and durability properties of the material compared with using red mud alone. Based on mechanical, economic and environmental benefits, it is recommended to use red mud in road base structure rather than in subgrade despite higher red mud consumption in subgrade than in road base. The scope for future research in this area is also suggested.

Key Words: Unconfined compression strength ,California bearing ratio ,Red mud.

1. INTRODUCTION

Laterite soil is rich in iron and aluminium, and it is generally considered to have formed in hot and wet tropical areas. Because of the presence of high iron oxide, almost all laterite soil is of rusty-red colour.

The sub grade should possess sufficient stability under adverse climatic and loading conditions so that it can provide adequate support to the pavement. Therefore, it is necessary to check the ability of the materials used as sub grade by conducting laboratory tests

In India, laterite soil is widespread, covering over 10% of the total geographical area, namely on the summits of the Western Ghats, Eastern Ghats (Rajamahal Hills, Vindhyas, Satpuras, and Malwa Plateau), southern parts of Maharashtra, parts of Karnataka, Andhra Pradesh, West Bengal Orissa, Jharkhand, Kerala, Assam, and Meghalaya

Red mud, also known as bauxite residue, is an industrial waste generated during the refinement of bauxite into alumina using the Bayer process. It is composed of various oxide compounds, including the iron oxides which give its red colour. Over 95% of the alumina produced globally is through the Bayer process; for every tonne of alumina produced, approximately 1 to 1.5 tonnes of red mud are also produced. Annual production of alumina in 2020 was over 133 million tonnes resulting in the generation over 175 million tonnes of red mud

Due to this high level of production and the material's high alkalinity, it can pose a significant environmental hazard and storage problem. As a result, significant effort is being invested in finding better methods for dealing with it.

2. LITERATURE REVIEW

The extensive literature review was carried out by referring standard journals, reference books and conference proceedings. The major work carried out by the different researchers is summarized below.

Sarat Kumar Das, Subrat Kumar Rout, Shamshad Alam [1] Characterization of Red Mud as a Subgrade Construction Material; Red mud is the industrial waste produced during the extraction of aluminium from bauxite. Globally, nearly

75 million tons of red mud is produced annually. The red mud is highly basic in nature with pH ranging from 10-13 and storage of such a large quantity of red mud needs large area of useful land. Also occasional failure of red mud tailing dam causes causalities, flooding of the land and mainly it pollute the surface water due to its high alkalinity. Hence to minimize the storage of red mud, it is required to utilize this waste as alternate engineering material.

Shaobin Wang *, H.M. Ang, M.O. Tadé [2] Red mud (RM) is a by-product of bauxite processing via the Bayer process. Its disposal remains an issue of great importance with significant environmental concerns. In the past decades, a lot of research has been done to utilize red mud for environmental-benign applications such as a building material additive and for metal recovery.

Jizhe Zhang, Zhanyong Yao, Kai Wang, Fei Wang, Hongguang Jiang, Ming Liang, Jincheng Wei, Gordon Airey [3] Sustainable utilization of the bauxite residue (red mud) generated from alumina refining has recently increased due to increased environmental concerns because of its high alkalinity and problematic pollutants when placed in landfills. This paper attempts to review recent research findings of utilizing red mud as a road material in pavement structures, including road bases and asphalt mixtures.

Ms. V. Janani, Mr. A. Gowtham [4] The Red mud is rich in Iron oxide which will improve the strength properties of the soil. The strength parameters of the treated and untreated soil werestudied by varying percentage of Red mud, starting from 5% up to 30% in the incremental order of 5%. From this study it was found that the maximum strength was obtained when 20% of the soil was replaced with the Red mud in terms Unconfined compression strength and California bearing ratio.

Sourabh Gupta1, Dr. Anil Kumar Saxena2 [5] The soil was stabilized with Red Mud in stepped concentration of 5%, 10%, 15%, 20%, 25% and 30% 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 20% the LL, PL,PI and decreases, while these parameters further increases in this limit beyond

David A. Rubinosa,∗ , Giovanni Spagnolib [6] The sorption of AsV on red mud (bauxite residue), produced in the ALCOA-San Cibrao factory (Spain), was assessed in view of its potential use as sorptive liner of landfills for the attenuation of As-rich leachates. The operating parameters evaluated, using batch-type procedures, comprised the effects of time, solution pH, AsV concentration (sorption isotherm) and presence of phosphate on the AsV sorption. The results showed that the red mud efficiently sorbed AsV . The sorption was fast, with a major fraction of initial AsV being removed in a few minutes or hours of contact, depending on AsV concentration.

Prasanna SB, DM Ajay Kumar, Bharath M, Pavan Kumar [7] Red mud is a sturdy residue Produced in the route of the alumina manufacturing through way of the bayer approach from bauxite. The red mud generated by means of this approach is surprisingly alkaline with pH commonly ranging from 10 to thirteen Due to its hazardous corrosive nature it's posing a very serious and alarming environmental problem. Globally there are about ninety million tones ofred mud being produced every and each and every year. More than 4 million tones of red mudis generated each year in India only.

Rameez Ahmad Mantoo, Dr. Esar Ahmad, Mr. Govind Singh Chauhan [8] Red mud is the industrial waste produced during the extraction of aluminium from bauxite. Globally, nearly 75 million tons of red mud is produced annually. The red mud is highly basic in nature with pH ranging from 10-13 and storage of such a large quantity of red mud needs large area of useful land. Also, occasional failure of red mud tailing dam causes causalities, flooding of the land and mainly it pollutes the surface water due to its high alkalinity. Hence to minimize the storage of red mud, it is required to utilize this waste as alternate engineering material. The main aim of this paper is to investigate the use of red mud in road construction as sub grade.

M. Aswathy, U. Salini & V. G. Gayathri [9] Large amount of industrial wastes are generated from various factories in India and are simply being disposed without any major applications. Alternative materials are to be adopted as a construction material so as to minimize the use of natural resources. Red mud (RM) is generated as a waste material during the production of alumina from bauxite, and it comes to around 40% of the bauxite used for the production. The paper presents the possibility of using red mud as a stabilizing material

Zubair Saing1, Lawalenna Samang2, Tri Harianto3 [10] Regional growth and development led to an increase in infrastructure especially roads. Along with that, material requirements as the road foundation also increased. Meanwhile, the number of qualified materials in certain areas is limited, difficult to obtain and expensive. Therefore, efforts are required to exploit the potential of local soils as a qualified road foundation material. One of them is laterite soil which is only wasted from mining activities.

Sarath Chandra K,1Krishnaiah S,1and Kibebe Sahile [11] Red mud is also a widespread industrial waste produced during aluminium extraction from bauxite ore in Bayer's process. Red mud is a highly alkaline material that creates a massive environmental threat in nature. To reduce the impact of this solid waste material, the ideal method is to use it in construction works with appropriate stabilization. This study envisages the strength properties of red mud with fly ash and cement to use it as a road construction material in

the subgrade. The influence of fly ash and cement on improving the strength properties of red mud was studied in detail by replacing red mud with 10%, 20%, and 30% with fly ash and 1%, 3%, and 5% of cement to its dry weight.

Azhar Afsar Pasha1, Pratiksha Malviya2 [12] 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.

Sudeshna Acharya [13] This study is about investigating the effect of red mud on the behavior of expansive soil by carrying out compaction tests, UCS and CBR tests for different percentages of soil-red mud admixture. Soil is stabilized with red mud varying from 10% to 40% withincrement of 10%. The test results show a considerable increase in MDD, UCS and CBR values. The MDD and OMC are increasing and maximum at 20% of red mud by weight of dry.

Kusum Deelwal1, Kishan Dharavath2, Mukul Kulshreshtha3 [14] This paper describes the characteristic properties of Red Mud and possible use as a geotechnical material. Basics properties like Specific gravity, Particle size distribution, Atter Berg's limit, OMC and MDD are determined. Engineering properties like shear strength, permeability and CBR values are also determined in conformity with the Indian Standard Code and test results are discussed in geotechnical point of view. It revealed that the behavior of red mud is likely as clay soil with considerably high strength compared to conventional clay soil.

Gayathri V G ,Salini ,U Aswathy M [15] Large amount of industrial wastes generated from various factories in India and are simply being disposed without any major applications. Alternative materials are to be adopted as a construction material so as to minimize the use of natural resources. Red mud (RM) is generated as a waste material during the production of alumina from bauxite and it comes to around 40% of the bauxite used for the production. The paper presents the possibility of using red mud as a stabilizing material. The study examines the effect of red mud on behavior of clays by carrying out compaction test, CBR tests and UCC tests for different percentages of red mud. The red mud soil mix is further treated with lime to understand if more soil can be replaced by red mud on lime treatment. It was seen that the highest Maximum Dry Density (MDD), UCS and CBR values were obtained for 15% red mud in soil. On further treatment with 2% of lime, 20% red mud in soil showed more strength compared to 15% red mud in soil ensuring that more soil can be replaced by red mud on treating with lime.

3. MATERIALS AND METHODOLOGY

Materials Used:

LATERITIC SOIL:

- Laterite soils are occasionally associated with geotechnical problems such as road deformation, erosion, settlement, dam seepage, slope instability, leachate permeation through hydraulic barriers, etc.
- Proposed research flow chart Laterite soils will be collected from burrow pits on site at a depth of about 1.0 m below the natural ground surface. This is to avoid the dense organic matter contents present at surface. Then, it will be taken to the geotechnical laboratory for experiment .

RED MUD:

- Discharge of red mud can be hazardous environmentally because of its alkalinity and species components.
- More than 4 million tons of red mud is generated annually in India only.
- In October 2010 approximately one million cubic meters of red mud slurry from an alumina plant near kolontar in Hungry was accidentally released into the surrounding country side in the Ajka alumina plant accident, killing ten people and contaminated large area

Methodology

To determine the general properties of soil specified tests are done by using different parts of IS 2720 which are as

a) Sieve analysis test

b) Specific Gravity test

c) Atterberg's Limit: -

- Liquid limit
- Plastic limit
- Shrinkage limit

d) Compaction test: -

- Optimum Moisture Content
- Dry Density

e) Unconfined compression test

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10% Red mud +90% Laterite Soil	2.280
20% Red mud +80% Laterite Soil	2.304
30% Red mud +70% Laterite Soil	2.525
40% Red mud +60% Laterite Soil	2.634

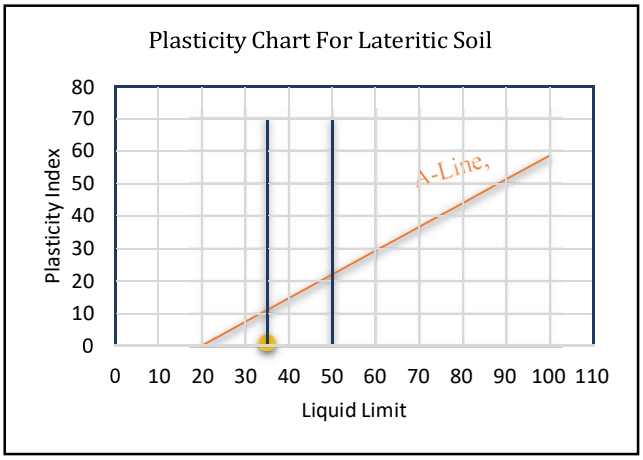
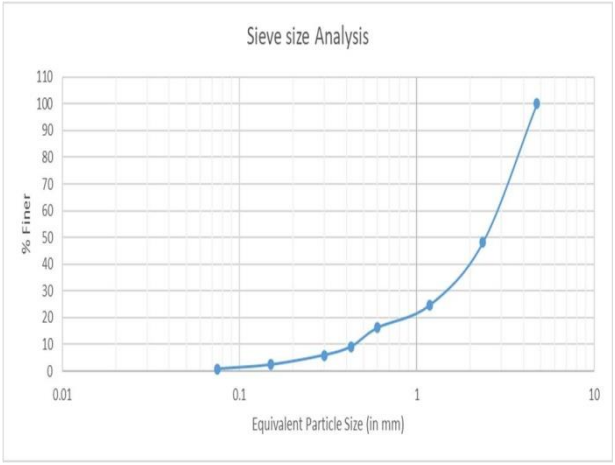


Fig-4.2: Graphical representation of Plasticity chart for lateritic soil

SIEVE ANALYSIS:



Graphical Representation of Sieve Analysis.

LIQUID LIMIT FOR 10% OF RED MUD

Moisture Content of the soil = (Ww/Wd)	31.34	30.65
Number of Blows, N	14	28

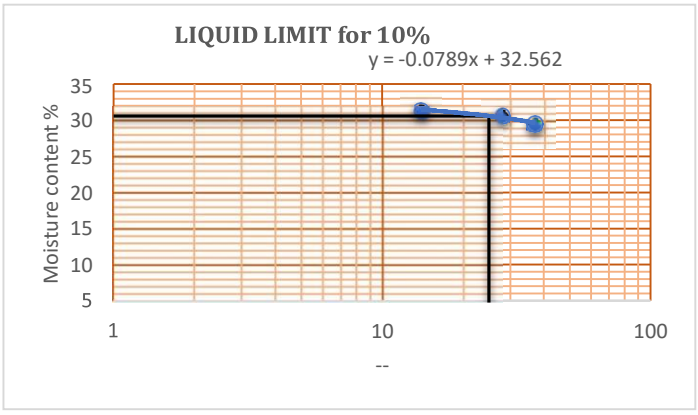


Fig-4.3: Graphical representation of Liquid Limit for 10% of red mud

4.2 SPECIFIC GRAVITY

Specific Gravity Of Lateritic Soil

Average Specific Gravity = 2.003

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1. **PLASTIC LIMIT FOR 10% OF RED MUD**

Plasticity index = 12.255

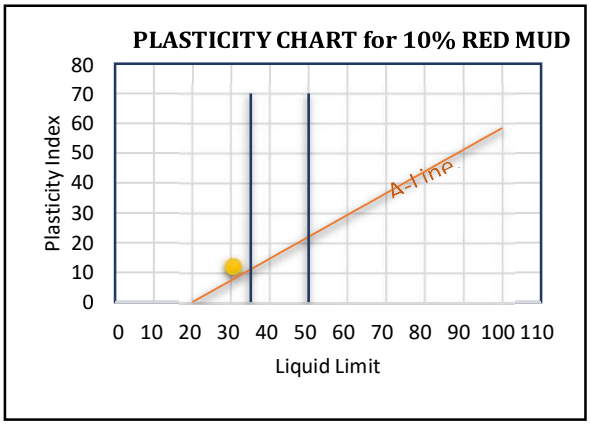

Fig-4.4: Graphical representation of Plastic Limit for 10% of red mud

2. **LIQUID LIMIT FOR 20% OF RED MUD**

Moisture Content of the soil = (Ww/Wd)	29.217	29.607
Number of Blows, N	13	26

Liquid Limit = 29.577

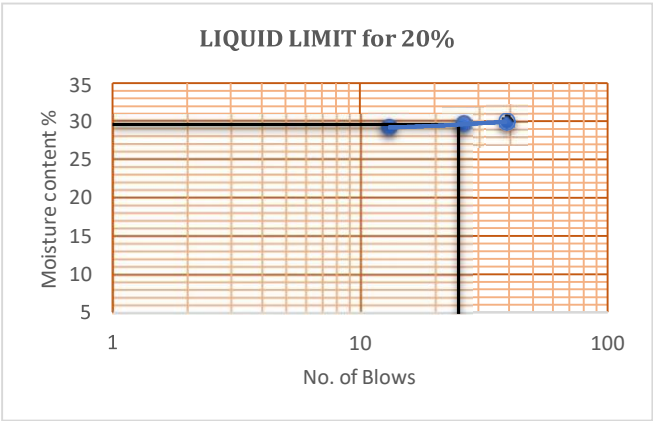

Fig-4.5: Graphical representation of Liquid Limit for 20% of red mud

3. **PLASTIC LIMIT FOR 20% OF RED MUD**
4. Plasticity index = 11.242

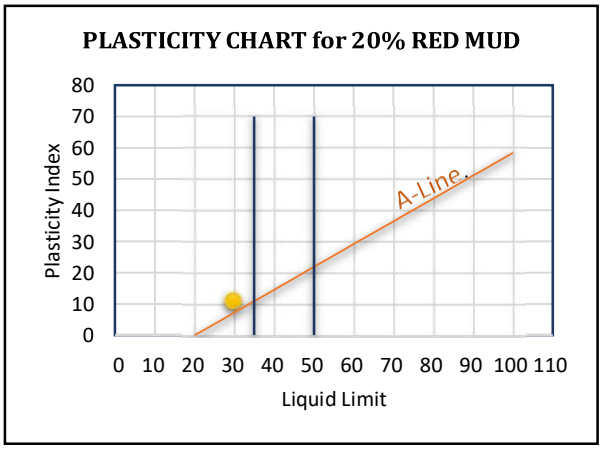

Fig-4.6: Graphical representation of Plastic Limit for 20% of red mud

5. **LIQUID LIMIT FOR 30% OF RED MUD**
6.

Moisture Content of the soil = (Ww/Wd)	26.883	27.143
Number of Blows, N	18	28

Liquid Limit = 27.065

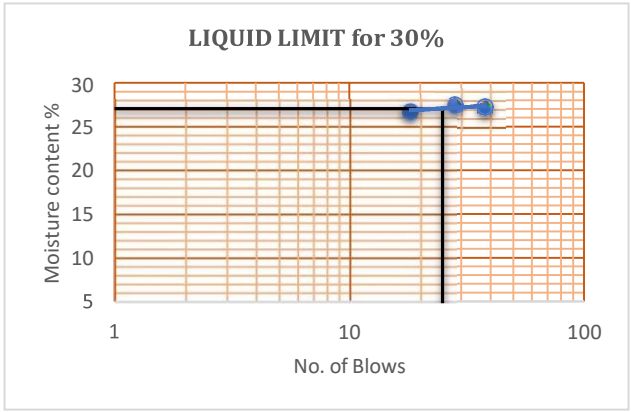

Fig-4.7: Graphical representation of Liquid Limit for 30% of red mud

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7. PLASTIC LIMIT FOR 30% OF RED MUD

Plasticity index = 8.73

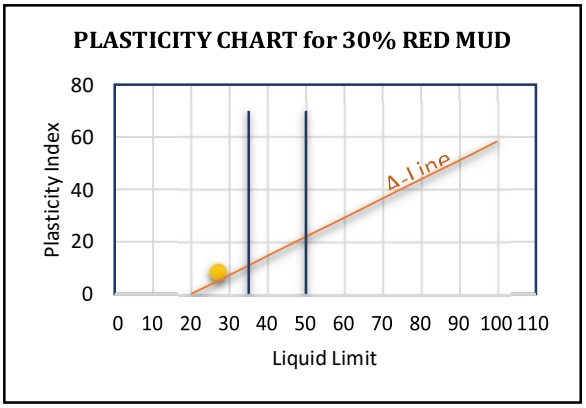

Fig-4.8: Graphical representation of Plastic Limit for 30% of red mud

8. LIQUID LIMIT FOR 40% OF RED MUD

Moisture Content of the soil = (Ww/Wd)	30.0428	26.4964
Number of Blows, N	14	27

Liquid Limit = 27.042

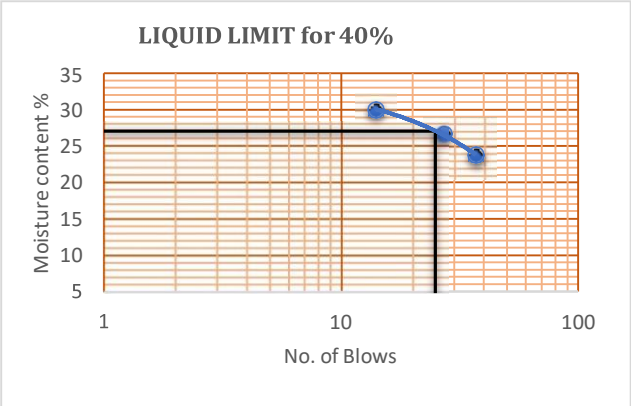

Fig-4.9: Graphical representation of Liquid Limit for 40% of red mud

9. PLASTIC LIMIT FOR 40% OF RED MUD

Plasticity index = 8.791

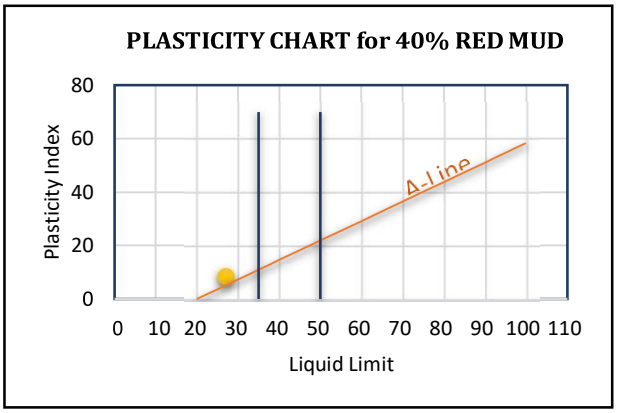

Fig-4.10: Graphical representation of Plastic Limit for 40% of red mud

COMPACTION TEST

Compaction is the application of mechanical energy to a soil so as to rearrange its particles and reduce the void ratio. To increase soil shear strength and therefore its bearing capacity, to reduce subsequent settlement under working loads and to reduce soil permeability making it more difficult for water to flow through.

1. COMPACTION FOR 10% OF RED MUD

Moisture Content	6.44	9.63	10.89	12.62	13.64
Dry Density	1.652	1.792	1.882	2.086	1.968

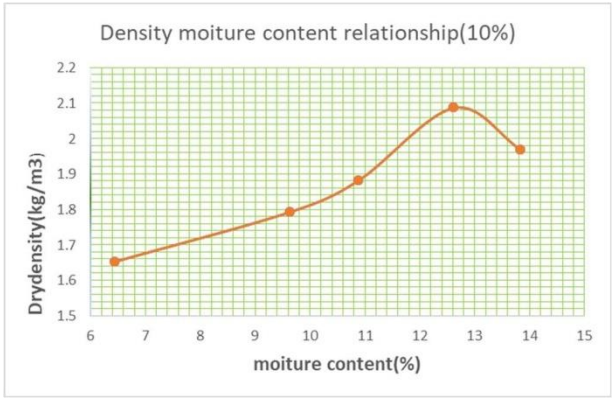

Fig-4.11: Graphical representation of Compaction for 10% of red mud

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2. COMPACTION FOR 20% OF RED MUD

Moisture Content	6.49	8.61	11.2	13.38	14.94
Dry Density	1.722	1.738	2	2.092	2.048

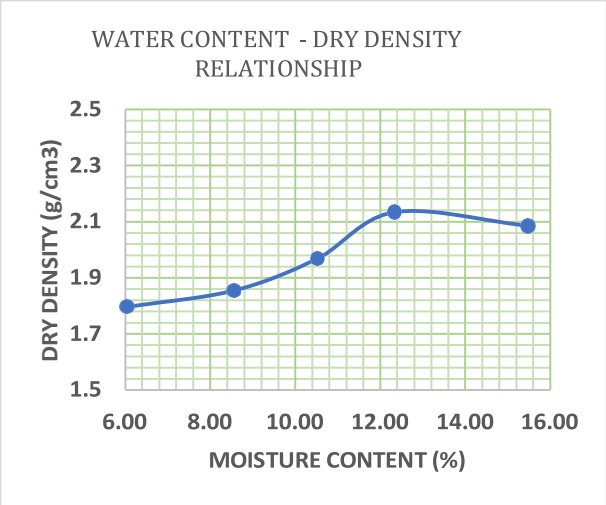

Fig-4.12: Graphical representation of Compaction for 20% of red mud

3. COMPACTION FOR 30% OF RED MUD

Moisture Content	6.04	8.55	10.52	12.34	15.47
Dry Density	1.76	1.854	1.968	2.134	2.086

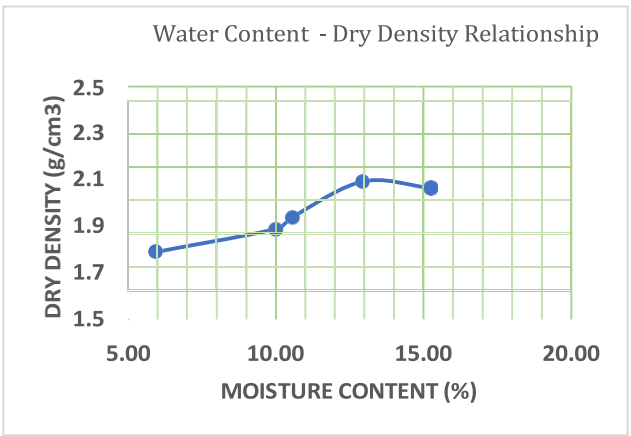

Fig-4.13: Graphical representation of Compaction for 30% of red mud

4. COMPACTION FOR 20% OF RED MUD

Moisture Content	5.93	10.00	10.55	12.93	15.24
Dry Density	1.79	1.888	1.938	2.092	2.064

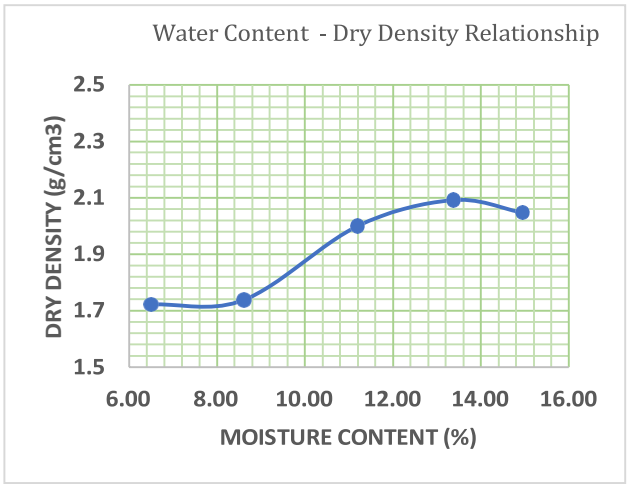

Fig-4.14: Graphical representation of Compaction for 40% of red mud

5. UNCONFINED COMRESSION TEST

Additive	UCS (Kg/cm2)
10% red mud +90% laterite soil	3.20
20% red mud+80% laterite soil	3.40
30% red mud+70% laterite soil	3.70
40% red mud+60% laterite soil	4.10

4 CONCLUSION

- From the California bearing ration test of the soil sample is 37.03%, which meet the required specification. So, it can be concluded that red mud can be used in road construction as subgrade.
- Due to presence of iron compound minerals, the specific gravity of red mud is very high as compared to soil. Red mud has higher MDD in comparison to other materials due to high specific gravity.
- Red mud has low plasticity and low volumetric and linear shrinkage with 90% of particle finer than 0.075mm. But, the angle of internal friction of the red mud is very high as compared to other fine grained soil.
- In this study we found that the specific gravity of laterite soil increases by increasing in the percentage of red mud.

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