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CONSTRUCTION OF ROAD SUB-BASE BY USING INDUSTRIAL WASTE

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ABSTRACT
The objective of the study was to evaluate the effectiveness and the behavior of red mud to be used as sub base and also sub grade for road construction. This paper describes the characteristic properties of Red Mud and possible use as a geotechnical material. Basics properties like Specific gravity, Particle size distribution, liquid limit, OMC and MDD are determined. Engineering properties like shear strength and CBR values are also determined in conformity with the Indian Standard Code and test results are discussed in geotechnical point of view. Using the OMC and MDD results, direct shear box test was carried out to obtain shear strength parameter c and ϕ and unconfined compression shear test was carried out to obtain unconfined compressive strength and shear strength.

INTRODUCTION
Industrialization and urbanization are the two world wide phenomena. Though these are the necessity of the society and are mostly inevitable, one has to look into their negative impacts on the global environment and social life. The major ill effect of these global processes is the production of large quantities of industrial wastes and the problems related with their safe management and disposal. Second problem is the scarcity of land, materials and resources for ongoing developmental activities, including infrastructure. One of the major challenges before the processing and manufacturing is industries disposal of the residual waste products. Red mud is one of the major waste products of any aluminum industry. Red Mud is produced during the process for alumina production. Depending on the raw material processed, 1–2.5 tons of red mud is generated per ton of alumina produced. In India, about 4.71 million tons/annum of red mud are produced. Generally the upper most layer of soil is used as sub grade for road construction, but this soil is very fertile which is generally used for cultivation. Hence, to reduce the use of this soil, red mud can be used as sub grade. As red mud is a toxic waste material, it can't be used for any other purposes. Disposal of large quantities of Red mud dumped, poses increasing problems of storage occupying a lot of space.

MATERIALS AND METHODS
RED MUD

Fig 1 : Oven Dried Red Mud

The redmud for this paper is taken from NALCO, Damonjodi, Odisha . Red mud is the solid waste residue of the digestion of bauxite ores with caustic soda for alumina (Al_2O_3) production. Approximately 35–40% of the processed bauxite ore goes into the waste as alkaline red mud slurry which consists of 15–40% solids and 0.8–1.5 tons of red mud is generated per ton of alumina produced. It is estimated that annually 70 million tons of red

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mud is produced all over the world, with 0.7 million tons in Greece, 2 million tons in India, 30 million tons in Australia and nearly 30 million tons in China.

Chemical Properties
The sample was tested in Regional Research Laboratory, Bhubaneswar, Odisha, and it was found that the sample contain the following substances.

Table 1: Chemical composition of Red Mud

Composition	Percentage
Al_2O_3	18.0
Fe_2O_3	51.0
TiO_2	4.6
SiO_2	9.8
Na_2O	5.3
CaO	1.8
P_2O_5	0.15
V_2O_5	0.035
Loss on ignition	9.05

METHODOLOGY
There are different properties of soil some of which are tested for red mud. These include:

A. Particle size distribution.
B. Specific gravity
C. Light compaction Test
D. Liquid Limit
E. Direct shear Test
F. Unconfined compressive strength Test
G. CBR
H. P^H VALUE:

A. PARTICLE SIZE DISTRIBUTION :

"Particle size distribution" is an index indicating what sizes (particle size) of particles are present in what proportions (relative particle amount as a percentage where the total amount of particles is 100 %) in the sample particle group to be measured.This test is done to determine the particle size distribution of soil as per **IS: 2720 (Part 4) – 1985**. The complete sieve analysis can be divided into two part such as the coarse analysis and fine analysis. An oven dried sample of soil is separated into two fractions by sieving it through a 4.75mm IS sieve. The portion retained on it(+4.75mm size) is termed as gravel fraction and is kept for course analysis, while the portion through it (-4.75mm sieve) is subjected to fine sieve analysis. The following set of sieves are used for fine sieve analysis are : 2.36mm, 1.18mm, 0.6mm, 0.425mm, 0.3mm, 0.15mm and 0.075mm IS sieve.
From our experiment the value of uniformity co-efficient is 4.77and co-efficient of curvature values is 0.6 of red mud.

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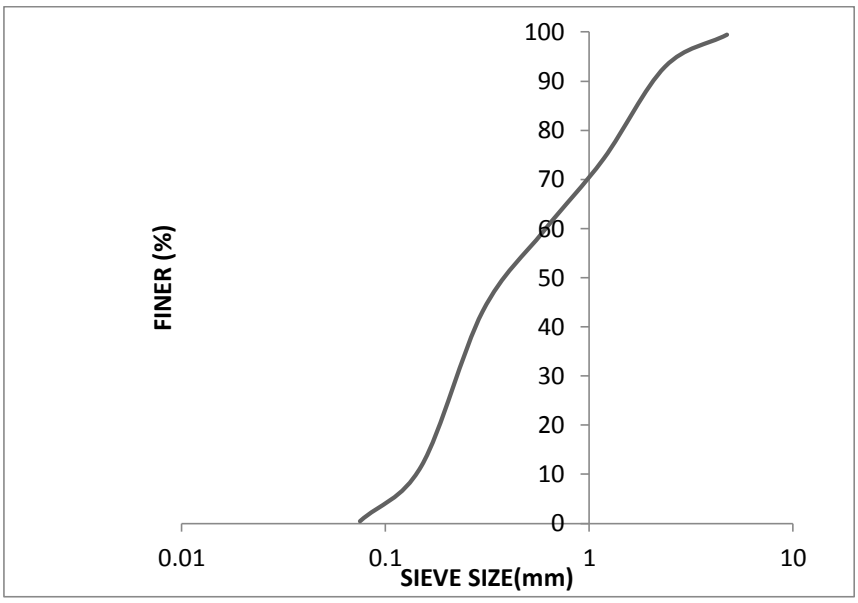

Fig 2 : Particle size Distribution curve

*B. **SPECIFIC GRAVITY** :*

"**Specific gravity"** is the ratio of the weight of a volume of the substance to the weight of an equal volume of the reference substance. This test is performed to determine the specific gravity of soil by using a pycnometer and density bottle. The specific gravity of a soil is used in the phase relationship of air, water, and solids in a given volume of the soil. This test involves determination of specific gravity carried out as per **IS: 2720 (Part III/sec 1) – 1980.** The soil solids have permeable and impermeable voids inside them, the permeable voids being capable of getting filled with water. If all the internal voids of soil particles (permeable and impermeable) are excluded for determining the true volume of solids, the specific gravity obtained is called absolute or true specific gravity.

The experiment was performed from both pycnometer method and density bottle. The specific gravity of the red mud was found to be 2.83-2.9.

C. LIGHT COMPACTION TEST:

Soil compaction is the process in which a stress applied to a **soil** causes densification as air is displaced from the pores between the **soil** grains. The **Proctor compaction test** is a laboratory method of experimentally determining the optimal moisture at which a given soil type will become most dense and achieve its maximum dry density. The term Proctor is in honour of R.R.Proctor, who in 1933 showed that the dry density of a soil for a given compactive effort depends on the amount of water the soil contains during soil compaction. His original test is most commonly referred to as the standard Proctor compaction test; later on, his test was updated to create the modified Proctor compaction test. Compaction curve is plotted between the water content as abscissa and the corresponding dry densities as ordinates. The dry density goes on increasing as the water content is increased, till maximum density is reached. The water content to the maximum density is called the optimum water content. The light/standard proctor compaction test was conducted as per code **IS: 2720 (Part 7) – 1980.** We are taking 2.5 kg of oven dried red mud and compacting it on a standard specified mould by adding increasing order of water content. From our experiment the value of Maximum dry density (MDD) and Optimum moisture content (OMC) was found to be 1.81 gm/cm^3 and 23.25 percent.

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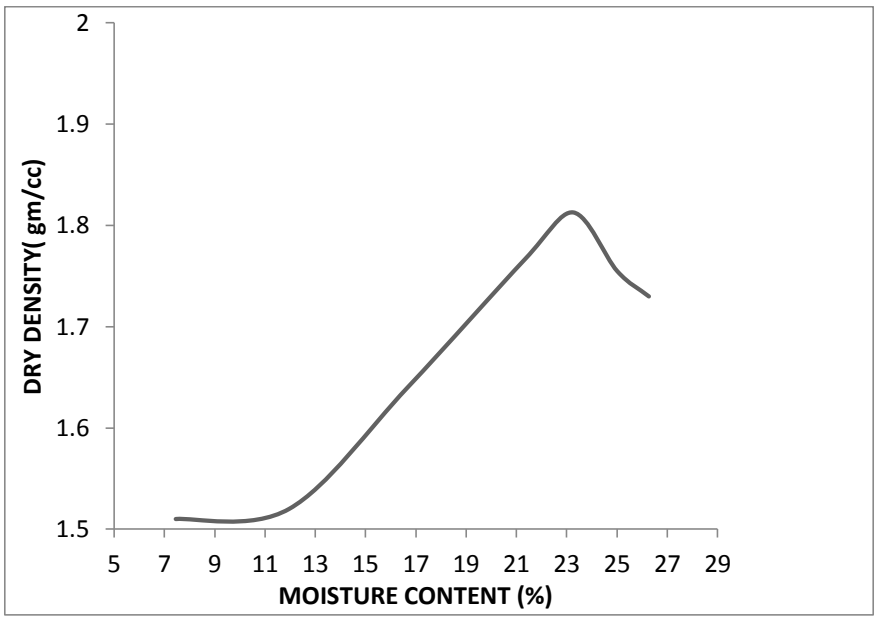

Fig 3 : Graph between OMC and MDD

Fig 4 : Cutting the surface by straight edge

D. LIQUID LIMIT:

Atterberg limits correspond to the moisture content at which a soil sample changes it's consistence from one state to the other. Liquid limit (LL) and plastic limit (PL) are two important states of consistence. **Liquid limit** is the minimum water content at which the soil is still in the liquid state, but has a small shearing strength against flowing which can be measured by standard available mean. The liquid limit of the sample was found to be 31.2%.

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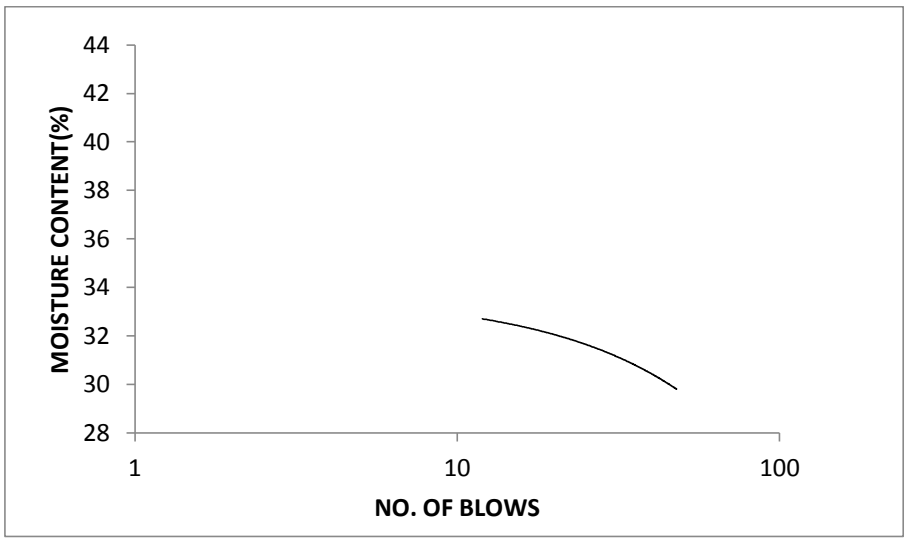

Fig 5 : Liquid Limit

E. DIRECT SHEAR TEST:

In many engineering problems such as design of foundation, retaining walls, slab bridges, pipes, sheet piling, the value of the angle of internal friction and cohesion of the soil involved are required for the design. Direct shear test is used to predict these parameters quickly. The advantages of the direct shear test over other shear tests are the simplicity of setup and equipment used, and the ability to test under differing saturation, drainage, and consolidation conditions. These advantages have to be weighed against the difficulty of measuring pore-water pressure when testing in un drained conditions, and possible spuriously high results from forcing the failure plane to occur in a specific location. The direct shear test is conducted as per **IS: 2720(Part 13) -1986.** The value of Cohesion (C) and angle of internal friction (φ) was found to be 0.12 1nd 28^0.

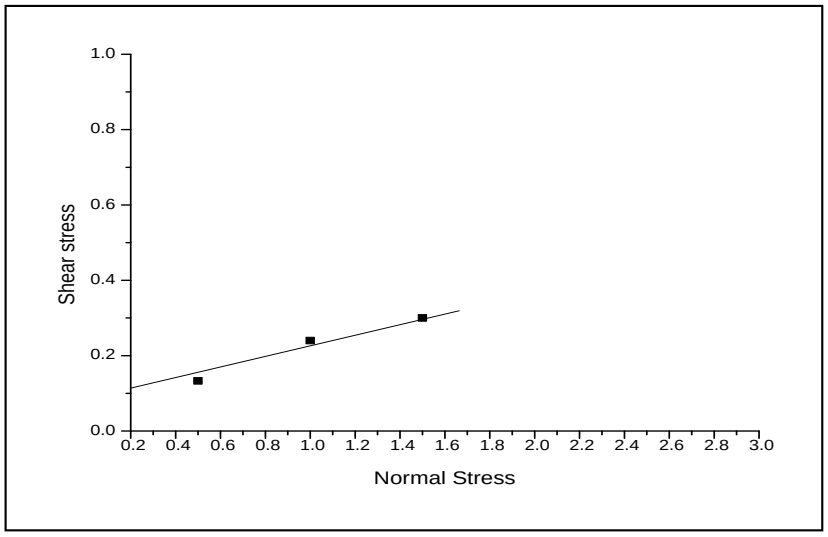

Fig 6 : Normal srress vs Shear stress

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F. UNCONFINED COMPRESSIVE STRENGTH TEST:

The unconfined compressive strength (q_u) is the load per unit area at which the cylindrical specimen of a cohesive soil fails in compression. Q_u =P/A, P is the axial load at failure and A is the corrected area.This test is conducted as per **IS: 2720 (Part 10)-1991.**

The samples of sizes 38 mm diameter and height of 76 mm were prepared by dynamic compaction method to achieve maximum dry density at their optimum moisture contents. The UCS value of red mud was found to be 191.01 kN/$m^{2.}$

G. CALIFORNIA BEARING RATIO:

The California bearing ratio (CBR) test was developed by the California division of highway as a method of classifying and evaluating soil sub-grade and base course materials for flexible pavements. The CBR is measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. The CBR test may be conducted in re-moulded or undisturbed specimen in the laboratory (we have used remoulded sample). The test is simple and has been extensively investigated for field correlation of flexible pavement thickness requirement.
The soaked and unsoaked CBR value was tested and it was found to be 4 and 7.5

H. P^H VALUE:

The p^H value of red mud sample was found to be 12. It is alkaline in nature**.**

RESULTS AND DISCUSSION

Table showing different properties of red mud which was found out by laboratory experiments.

Table 2: Properties of Red Mud

Sl. No.	Properties of Red mud		Values
1.	Sieve analysis	C_u	4.77
		C_c	0.6
2.	Sp. Gravity (G)		2.83-2.9
3.	Optimum Moisture content (%)		23.25
4.	Max. dry Density (gm/cc)		1.81
5.	Liquid Limit (%)		31.20
6.	C (kg/cm^2)		0.12
7.	Φ(degree)		28
8.	Unconfined Compression q_u (kN/m^2)		191.01
9.	CBR	Soaked	4
		Unsoaked	7.5
10.	p^H		12

The above mention table shows the properties of Red mud. From the p^H value it was clarify that Red mud is fully alkaline in nature. From the Chemical analysis it was found that red mud contain mora that 50% of iron oxide, so the colour of this mud is Red.

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CONCLUSION

- Specific gravity of the red mud is nearly equal to 2.9 which is very high compared to the soil solids. So the density of red mud will be more and so the strength is more.
- The cohesive strength and the angle of shear resistance obtained from the triaxial test are 0.123kg/cm2and 28 The strength value of the red mud is higher than the conventional clay material.
- CBR value of the red mud in soaked condition is 4% which is greater than the 3%, so we can use the red mud as a road material in village side.
- From the properties it was seen that it can be used as a good filler material.
- Valuable top soil is saved by construction the road sub base by using red mud.

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REFERENCES

1. K Deelwal, K Dharavath, M Kulshreshtha Evaluation Of Characteristic Properties Of Red Mud For Possible Use As A Geotechnical Material In Civil Construction, International Journal of Advances in Engineering & Technology, July, 2014.©IJAET ISSN: 22311963.
2 R. K. Paramguru, P. C. Rath, and V. N. Misra, Trends in red mud utilization - a review, Mineral Processing & Extractive Metallurgy Review, vol. 26, no. 1, pp. 1–29, 2005.
3. Suchita Rai, K.L. Wasewar, J. Mukhopadhyay, Chang Kyoo Yoo, Hasan Uslu Neutralization and utilization of red mud for its better waste management ARCH. ENVIRON. SCI. (2012), 6, 13 -33
4. U. V. Parlikar, P. K. Saka, and S. A. Khadilkar, Technological options for effective utilization of bauxite residue (Red mud) — a review, in International Seminar on Bauxite Residue (RED MUD), Goa, India, October 2011.
5. Satapathy BK, Patnaik SC, Vidyasagar P (1991). Utilisation of red mud for making red oxide paint. INCAL-91, International Conference and Exhibition on Aluminium at Bangalore, India 31st July-2nd Aug. 1991 (1): 159-161.
6. Yang JK, Chen F, Xiao B. Engineering application of basic level materials of red mud high level pavement (In Chinese). China Munic. Eng. 2006;(5):7−9.