International Journal of Research
Available at https://edupediapublications.org/journals

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 14
November 2017

A Study ofProperties of RedMud for possible use as a Geotechnical Materialin Civil Construction

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ABSTRACT: *Red mud a real solid waste\byproduct produced from the digestion of bauxite orewith caustic soda for the production of alumina.During the past decades, extensive work has been done by a lot of researchers to develop variouseconomic ways for the utilization of red mud.This paper designates the characteristic properties of Red Mud and possible use as ageotechnical material. Basics properties like Specific gravity, Particle size distribution, Atter Berg's limit, OMCand MDD are determined. Engineering properties like shear strength, permeability and CBR values are alsodetermined in conformity with the Indian Standard Code and test results are deliberated in geotechnical point ofview.*

KEYWORDS-Red mud, Characterization, disposal, Neutralization, Comprehensive utilization.

I. INTRODUCTION

Red mud is the strong waste residue of the absorption of bauxite ores with caustic soda foralumina (Al_2O_3) manufacturing. Approximately 35–40% of the processed bauxite ore goes into thewaste as alkaline purple mud slurry which consists of 15–40% solids and 0.8–1.5 heaps of red dust isgenerated consistent with ton of alumina produced. It is anticipated that yearly 70 million tons of crimson mud isproduced all around the international, with 0.7 million heaps in Greece [1], 2 million lots in India [2], 30million heaps in Australia [3], and almost 30 million heaps in China. As a strong waste, purple mud iscommonly disposed in dust lakes inside the form of slurry impoundment or stack in ponds as dry dustclose to alumina flora, or without delay discharged via a pipeline into a nearby sea. Due to thetraits of quality debris, excessive alkalinity (pH 10–12.5) and hint steel content, the disposalof huge portions of crimson mud has brought about serious environmental troubles together with soilinfection, groundwater pollution and satisfactory particles' suspension in the sea. Moreover, thestorage of pink dust in lakes or ponds occupies massive regions of land, and the storage of dry purple dustcan also cause dirt pollutants that's a serious fitness issue for the human beings living near the reddust storage ponds. The cost of red mud disposal is high-priced, accounting for approximately 2% of thealumina cost [4]. For example, the alumina cost is ready US$439 according to ton in China, so thedisposal value of crimson mud would be nearly US$9 per ton of alumina production. Over the years,huge work has been finished via researchers worldwide to develop diverse financial ways forthe usage of pink soil. The diverse packages which have been investigated encompass: (i) as astabilization fabric for the guidance of liners[5]; (ii) as adsorbents for the removal of heavymetals, dyes, phosphate, nitrate and fluoride[6]; (iii) practise of catalysts; (iv) healing ofiron, aluminum, titanium and other hint metals[7]; (v) production of radiopaque substances[8];(vi) education of ceramics [9]; (vii) production of creation bricks[10];(viii) improvement ofpigments and paints [11]; and (ix) preparartion of cements[12].

II. BACKGROUND WORK

The production of caustic red mud makes the Bayer process an environmentallychallenging process. Red mud, which derives its name from the color of iron oxides in thesubstance, comprises up to 60% of the bauxite material, depending on the ore. For each tone ofalumina produced, up to two tones of red mud are generated. The exponential growth rate of thequantity of red mud in the word, driven by global consumption of aluminum, is a majorenvironmental concern for the aluminum industry and a hazard for the communities andecosystems near production facilities.

The production process of alumina is shown is Fig.1. In the Bayer process, bauxite isdigested by leaching it with a hot solution of sodium hydroxide, NaOH, at 106-240°C and at 1-6atm pressure. This converts the aluminum minerals into tetrahydroxidoaluminate$Al(OH)_4$, whiledissolving in the hydroxide solution. The other components of bauxite except silica (present inkaolinite) do not dissolve. The insoluble compounds are separated by settling and the decantsolution is further clarified by filtering off remaining solid impurities. The waste solid is washedand filter pressed to regenerate caustic soda and is called red mud presenting a disposal problem.Next, the hydroxide solution is cooled, and the dissolved aluminum hydroxide precipitates as awhite, fluffy solid. When heated to 1050°C (calcined), the aluminum hydroxide decomposes toalumina, giving off water vapor in the process. A large amount of the alumina so produced isthen subsequently smelted in the Hall Heroult process in order to produce aluminum.In the sintering process, the crushed bauxite ores are usually mixed with limestone andcaustic soda, and the mixture is sintered at a high temperature of about 1200°C to form solublesodium aluminate upon addition of water or diluted alkaline solution. The sintering process issuitable for refining bauxite ore with Al_2O_3/SiO_2,(A/S) values of 3–6. In addition, thecombination of Bayer process and sintering process is also used in some of the Chinese aluminaplants with large productions such as Zhengzhou Aluminum Plant, Guizhou Aluminum Plant andShanxi Aluminum Plant. The combination process is used for refining bauxite ores with A/S>4.5.

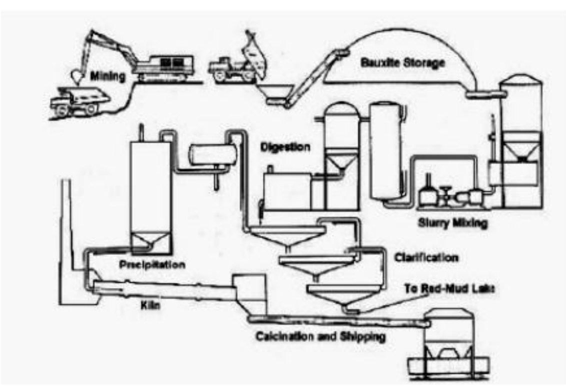

Fig.1. Production process for Alumina; Source: [University of West Indies]

No matter what the production process is, the chemical composition of red mud containssix major constituents, Chemical analysis shows that red mud contains silicium, aluminium, iron,calcium, titanium, sodium as well as an array of minor elements namely K, Cr, V, Ba, Cu, Mn,Pb, Zn, P, F, S, As, and etc. The variation in chemical composition between red mud worldwideis high. Typical composition of red mud is given in Table-1 [13].

Table.1 Typical composition of red mud

Composition	Weight %
Fe_2O_3	30-60
Al_2O_3	10-20
SiO_2	3-50
Na_2O	2-10
CaO	2-8
TiO_2	Trace-25 %

Standard Proctor test was carried out to determine the maximum dry density and optimum moisturecontent of the red mud. The test is carried out as per the IS: 2720 (Part VII) Light compaction wasadopted. The variation of water content and the corresponding water content variation is shown inthefig:2

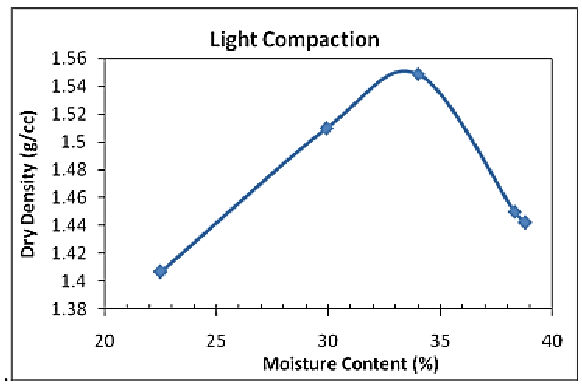

Fig-2: Graph showing water content and dry density

III. THE SUGGESTED APPROACH

Comprehensive utilization of red mud in construction

A. Red mud in cement replacement: Dicalcium silicate in red mud is also one of the main phases in cement clinker, and red mud can playthe role of crystallization in the production of cement clinker. Fly ash is mainly composed of SiO_2 andAl_2O_3, thus can be used to absorb the water contained in the red mud and improve the reactive silicacontent of the cement. Scientists conducted a series of studies into the production of cement using redmud, fly ash, lime and gypsum as raw materials. Use of red mud cement not only reduces the energyconsumption of cement production, but also improves the early strength of cement and resistance tosulfate attack [6].

B. Concrete industry: Red mud from Birac Alumina Industry, Serbia was tested as a pigment for use in the building materialindustry for standard concrete mixtures. Red mud was added as a pigment in various proportions(dried, not ground, ground, calcinated) to concrete mixes of standard test blocks (ground limestone,cement and water) [7]. The idea to use red mud as pigment was based on extremely fine particles ofred mud (upon sieving: 0.147mm up to 4wt%, 0.058 mm up to 25 wt% and the majority smaller than10 microns) and a characteristic red colour. Compressive strengths from 14.83 to 27.77 MPa of theblocks that contained red mud between 1 and 32% were considered satisfactory. The reported testshave shown that neutralized, dried, calcined and ground red mud is usable as pigment in the buildingmaterials industry. Red oxide pigment containing about 70 % iron oxide was prepared from NALCOred mud by [8] after hot water leaching filtration, drying and sieving.

C. Red mud in the brick industry: D. Dodoo- Arhin, et al [9] have been investigated bauxite red mud-Tetegbu clay composites for theirapplicability in the ceramic brick construction industry as a means of recycling the bauxite waste. Theinitial raw samples were characterized by X-ray diffraction (XRD) and thermo gravimetric (TG)analysis. The red mud-clay composites have been formulated as 80%-20%, 70%-30%, 60%-40%,50%-50% and fired at sintering temperatures of 800ºC, 900ºC and 1100ºC. Generally, mechanicalstrengths (modulus of rupture) increased with higher sintering temperature. The results obtained forvarious characterization analyses such as bulk densities of 1.59 g/cm3 and 1.51 g/cm3 compare verywell with literature and hold potential in bauxite residue eco-friendly application for low-costrecyclable constructional materials. Considering the physical and mechanical properties of thefabricated brick samples, the batch formulation which contained 50% each of the red mud andTetegbu clay is considered the best combination with optimal properties for the construction bricksapplication and it could be employed in lighter weight structural applications.

IV. EXPERIMENTAL SETUP

Red mud primarily contains elemental compositions such as Fe_2O_3, Al_2O_3, SiO_2, CaO, Na_2O and K_2O.Besides, it also contains other compositions, such as Li_2O, V_2O_5, TiO_2 and ZrO_2. For instance, thecontent of TiO in red mud produced in India can be as much as 24%. Because of the huge amount ofred mud, value elements like Ga, Sc, Nb, Li, V, Rb, Ti and Zr are valuable and abundant secondaryresources. Therefore, it is of great significance to recover metals, especially rare earth elements, fromred mud.

Due to the characteristics of a high iron content, extensive research into the recovery of iron fromBayer process red mud have been carried out by scientists all over the world. The recycling process ofiron from red mud can be divided into roasting magnetic recovery, the reducing smelting method, thedirect magnetic separation method and the leaching extraction method, according to the differentways of iron separation. Researchers in Russia, Hungary, America and Japan have carried out ironproduction experiments from red mud. Researchers from the University of Central South have madesteel directly with iron recovered from red mud.

V. CONCLUSION

Specific gravity of the red mud is 3.04 which is very high compared to the soil solids. So thedensity of red mud will be more and so the strength is more. So the soil can be used as an embankment material, backfill material etc. From the Atter berg's limits it is concluded that the plasticity Index of the red mud is13.2. So,according to the IS classification based on plasticity A-line, the soil falls under ML. Means it ,is silt with low compressibility. The maximum dry density and optimum moisture content of the red mud is 1.53gm/cc and33.5% Respectively. Co-efficient of permeability of red mud is 5.786e-7cm/s which shows that permeability isvery low. Low permeable materials can be used for construction of earthen dams, roadembankments etc. The cohesive strength and the angle of shear resistance obtained from the triaxial test are0.123kg/cm2 and 26.80. The strength value of the red mud is higher than the conventional claymaterial.

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e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 14
November 2017

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