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Original Research Paper

Assessment of Red Mud Characteristic Aspects for Possible Geotechnical Material Use in Civil Construction

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ABSTRACT

When alumina is extracted from bauxite, a byproduct known as red mud is created. The Bayers Process is the name of the procedure. It is an insoluble substance that is produced when sodium hydroxide and bauxite are digested at high pressure and temperature. The unique qualities of red mud and In this study, its possible application as a geotechnical material is examined. It establishes basic characteristics. In compliance against the I.S. Code, engineering attributes such as shear strength, permeability, and CBR values are also calculated, and test findings are examined from a geotechnical perspective. It showed that, in comparison to regular clay soil, red mud probably behaves like clay soil with a significantly higher strength.

Keywords: Red Mud, Geotechnical, Bayer's Process

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1. INTRODUCTION

Red mud is the waste that is created when alumina is made from bauxite using the Bayer technique. Another name for it is bauxite residue. Under the Hazardous and Other Wastes category.RM is categorized. as a "High Volume little Effect Waste." The two global trends are urbanization and industrialization. Even though they are societal necessities and mostly unavoidable, one must consider their detrimental effects on the environment and social life worldwide. Large-scale industrial waste creation and issues with its safe management and disposal are the main negative effects of these worldwide activities. The lack of land, materials, and resources for continuous infrastructure development is the second issue. The process of producing alumina results in the formation of red mud. For each tonne of alumina generated, 1 to 2.5 tons of RM are created, depending on the raw material treated. Approximately 4.71 million tons of red mud are generated annually in India, representing 6.15% of all sodium hydroxide digestion world wide at high pressure and heat.. It is a mixture of compounds that were first present in the parent material, bauxite, as well as compounds that were added or produced during the Bayer cycle. It is thrown away of as a high-ionic-strength slurry with a pH of 10–13 and a solid content of 10–25%..

Around the world, a lot of research and development is being done on how to store, dispose of, and use red mud. An outline of the fundamental properties of red mud is given in this article. A summary of the primary methods of thorough usage is also provided. It details the development of both broad use and experimental research. The objective is to offer some useful data to better address the all-encompassing use of red mud. There are two primary stages to the current work. i) Conducting experiments and ii) Applying RM as a construction material. It isseparated into two sections in experimental works: tests to determine engineering qualities and tests to determine index properties. The potential use of RM as a geotechnical material is discussed in the second stage of the project. The main solid byproduct of the Bayer procedure is RM. Since the waste may be transported by runoff to surface streams of water throughout the monsoon months and may pollute ground water through leaching, the usual technique of disposal of RM in ponds can occasionally have detrimental environmental repercussions. Furthermore, pouring a lot of red mud all at once causes storage problems and takes up a lot of room.

2. CHARACTERISTICS PROPERTIES

2.1 BASIC PROPERTIES

2.1.1 **SPECIFIC GRAVITY**- In accordance with IS: 2720 (Part II) 1980, the red mud's specific gravity was determined. The experiment was conducted using a density bottle and the pycnometer technique. The red mud's specific gravity was determined to be 3.04.

2.1.2 **DISPERSION OF PARTICLE SIZE:** The RM Particle Dimension Distribution Was determined using IS: 1498–1970. Wet sieve analysis is done because the materials are over 90% silt and clay. To ascertain the particle size variation, the particles that passed from 75 micron were collected and subjected to hydrometer examination. The proportion of the entire mass that made it through the 75 micron sieve was around 87.32%. Figure 1 plots the grain diameter against the percentage finer.

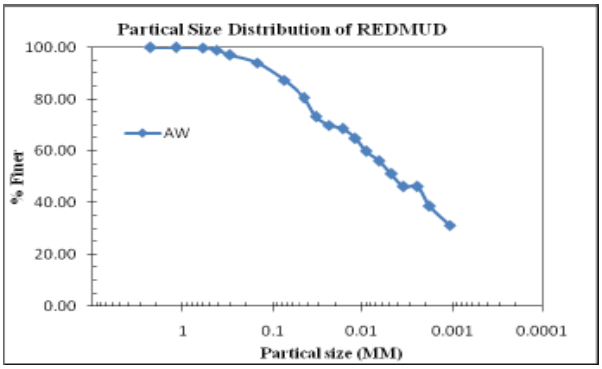

Figure-01. Particle Size Distribution Graph with % Finer

The red mud's maximum dry density and ideal moisture content were ascertained using the typical Proctor exaam. The test is administered in compliance with IS: 2720.. The compaction was light. The water percentage change and its corresponding change are depicted in Figure 2. The water percentage change and its corresponding change are depicted in Figure 2.

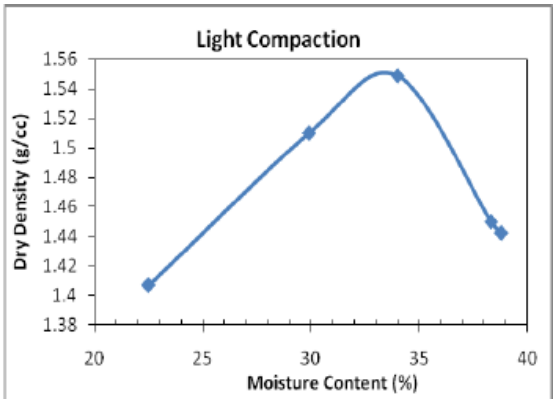

Figure-02. A Graph Displaying The Moisture Content And Dry Density.

In accordance with IS: 2720 (Part V), Atter Berg's red mud boundaries were established. The table displays the corresponding Plasticity measure, limits of plasticity, and liquid constraint: 01

Table-01. Physical and strength Parameters of Red Mud

S.NO	Tests		Values
1	Maximum dry Density (g/cc)		1.53
2	Optimum moisture Content (%)		33.5
3	Specific Gravity		3.04
4	Liquid Limit (%)		45.5
5	Plastic Limit (%)		32.3
6	Classification		ML
7	Cohesion (kg/cm^2)		0.123
8	Angle of internal friction(in Degree's)		26.8
9	CBR (%)	Soaked	4.2
		Unsoaked	7.8

2.2 CHEMICAL COMPOSITION OF RED MUD

The characteristics of the Bayer refinery circuit and variations in the bauxite input produce variations in the Red Mud's composition and characteristics.

Additionally, chemical processes inside the leftover body over time would change the content and qualities of Red Mud if it were to be mined again from the storage region. As a result, the usage strategy would also differ. Since using fresh residue is probably going to have more of an impact on the environment, it could be crucial. Fine mud particles make up the majority of red mud. Depending on where the bauxite comes from and how the alumina is made, As it is stacked up, its phase, content, and characteristics will change. According to chemical analysis, red mud includes a variety of elements, including K, Zn, S,Cr, V, Ba, F, Cu, Mn, Pb, P, As, and

others, as silicium, aluminum, iron, calcium, titanium, and salt. Chemical and mineral makeup of RM generated by the Bayer technique is listed in Tables 2 and 3.

Table: 02. RM CONSTITUTION

CONSTITUTION	PERCENTAGE
Hematite (Fe_2O_3)	30-70%
Al_2O_3	15-20%
S_iO_2	3-40%
Na_2O	2-12%
CaO	2-7%
TiO_2	Trace-20%

2.3 PROPERTIES ASSOCIATED WITH ENGINEERING

2.3.1 Permiability Test- Testing for permeability is done in accordance with IS: 2720 (Part XVII). The falling head technique is used to determine the red mud specimen's coefficient of permeability. It was discovered that the permeability coefficient was 5.786e- 7cm/s.

2.3.2.. CBR Test: A sample weighing about 4.5 to 5 kg was compressed into 5 layers in a 2250cc mold, with 56 blows applied to each layer. A separate sample of the same size is created and allowed to soak for four days with a surcharge in order to determine the soaked CBR value. This test was carried out in accordance with IS: 2720. The test findings are listed in Table 1.

2.3.3. Triaxial Compression Test- Clayey soil is the ideal material for the Triaxial Compression Test. The sample measures 36 mm in diameter by 75 mm in height. Once confining pressurehas been applied, deviator stress is applied till failure. Plotting of Mohr's stress circles requires at least two readings. The failure envelope, cohesiveness, angle of the internal friction, and shear characteristics are represented by A line that is tangent to the rings of Mohr. Table 1 displays the results.

2.3.4. Unconfined Compressive Strength: The static compaction method was used to create samples with a diameter of 36 mm and a height of 75 mm. This allowed for the greatest dry density at the ideal moisture level. Tests of unconfined compressive strength were performed at a strain rate of

1.25 mm per minute. Table 1 tabulates the results collected.

3. USES OF RED MUD

3.1. RED MUD IN BRICKS

The suitability of bauxite RM-Tetegbu clay composite for recycling bauxite waste in the

ceramic block building sector has been examined by D. Dodoo-Arhin et al. Using thermogravimetric (TG) and X-ray diffraction (XRD) examination, the original raw samples were described. 80%-20%, 70%-30%, 60%-40%, and 50%-50% are the formulations of the red mud-clay composites, which are then burnt at sintering temperatures of 800°C, 900°C, and 1100°C. Higher sintering temperatures often resulted in higher mechanical strengths (modulus of rupture). The bulk densities of 1.48 g/cm^3 and 1.41 g/cm^3 obtained from various characterization investigations show promise in an environmentally friendly application of bauxite residue for inexpensive recyclable building materials, and they compare extremely well with previous findings. According to the mechanical and physical features of the brick samples that were generated, the batch formulation that contains half Tetegbu clay and half red mud is believed to have the optimum properties for usage in building bricks and may be utilized in lighter structural applications.

3.2. CEMENT WITH RED MUD

In cement concrete, dicalcium silicate constitutes one of the main components. and RM may aid in crystallization at any point throughout the production process. Due to its primarily SiO_2 and Al_2O_3 composition, Fly ash can be used to increase the amount of reacting silica in the cement and soak the water in the red mud. The technique of creating cement from simple ingredients which include plaster of Paris, volcanic ash, lime, and RM was examined by researchers. In addition to lowering the energy required to produce cement, using RM cement increase the cement's premature strength and defense against sulfate assault.

3.3. RED MUD IN CONCRETE

RM was investigated as a pigment for use in common concrete mixes used in the building material sector. Red mud was used as a color in concrete combinations of typical test blocks in different amounts (dry, not ground, ground, and calcinated). Its characteristic red hue and extremely fine RM particles (sieving: 0.157 mm up to 4 weight percent, 0.056 mm up to 24 weight percent, and the majority smaller than 10 microns) were the basis for the idea of using red mud as pigment. Blocks containing 1–32% red mud had compressive values ranging from 14.83 to 27.67 MPa, which were deemed adequate. Red mud that has been neutralized, dried, calcined, and crushed can be used as a pigment in the construction materials sector, according to the tests that have been publishedRed oxide pigment was created from NALCO red mud, which contained about 70% iron oxide, following hot water leaching, filtering, drying, and sifting.

3.4. RED MUD IN ROAD

The use of red mud from the sintering process to create high-grade road base material is encouraging and might result in widespread red mud usage. Red mud is recommended as a road material by Qi. Using red mud as a basis material, a highway of 15 meters in width and 4 kilometers in length was built in Zibo, Shandong, based on the work of Qi. After testing the road's strength andsubgrade stability, a relevant department determined that RM base road satisfies the highway's strength criteria.

3.4. RED MUD IN ALUMINIUM INDUSTRY

In addition to producing aluminum, alumina from bauxite ore is utilized for non- metallurgical purposes, which account for around 10% of all end uses worldwide. Paper sizing, ceramics, abrasives, petroleum processing, plastic, flame retardants, fake marble, refractory materials, water purification, and medicines are a few examples. Portland cement, refractory material, abrasives, mineral fibers, steel, and calcium aluminate cements are among the products that employ bauxite in addition to alumina.

3.5. SOIL EMENDMENT

RM's use in environmental restoration has been well studied, despite the fact that it is tainted with heavy metals. The RM's ability to repair heavy metals makes it a potentially effective soil amendment. Unlike organic contaminants in the soil, heavy metals are not as biodegradable and are always present. The RM has a major impact on eliminating heavy metals from polluted soil and can readily adsorb various metal ions.

3.6. CATALYSIS

The cost of using catalysts can be reduced by using industrialized wastes that include Metals with catalytic activity as Ni, Fe, V, etc. instead of commercial catalysts. A viable substitute catalyst on a commercial scale is the RM, which is mostly composed of inorganic oxides of Fe, Al, and Ti with trace quantities of Si, Na, and Ca. Because several metal oxides are present in the RM composition at the same time, it is less vulnerable to catalyst poisons like sulfur and may thus maintain its catalytic activity for a comparatively long time.

3.7. CERAMIC PRODUCTION

Other RM application areas are the source of the

creation of ceramic goods such lightweight ceramic flooring, glass ceramic foam materials, double-layer glass-ceramic tiles, and roof tiles and bricks. Double-layer glass-ceramic bricks may be made from the RM to create visually beautiful building materials, according to the micro structural and mechanical features shown. RM, volcanic ash, and $CaCO_3$ can be used as a foaming agent at a low sintering temperature to create low bulk density glass ceramic foams. It is possible to manufacture ceramic tiles with acceptable qualities by substituting 30 weight percent of RM that contains low sodium hydroxide for natural clay and using calcinations temperatures higher than 950°C. The right amounts of RM, water, and silicon dioxide might be used to create ceramic blocks with greater permeability to water and significantly lower pH and conductivity.

3.8. BACKFILLING OF BAUXITE MINES

Following a pre-feasibility study, the possibility of disposing of Red Mud filter cake in backfilling bauxite mining pits may be taken into consideration. Additionally, on a case-by-case (location-by-location) basis, a pre-feasibility study should be carried out to address site-specific concerns of safety, surface runoff, leachate management, permeability, compaction, and other technical considerations. The department must secure the required permissions from the Department of Mines, the Ministry/Department of Environment, SPCBs/PCCs, and others as needed.

4. SUMMARY AND CONCLUSION

1. Considering all of these characteristics, we may use red mud as a geotechnical material for backfill, road subgrade, and embankment. Lime, gypsum, fly ash, and other materials are used to further stabilize red mud and increase its strength.
2. 2. In contrast to the solids of the soil, the RM's specific gravity of 3.04 is extremely high. Consequently, red mud will have a higher density and strength.
3. 3. The mud's small, well-graded grains are seen in Figure 1's particle size distribution graph. Thus, the soil can be used for embankment, backfill, and other uses..
4. The red mud's ideal water content is 32.5%, and its highest dry density is 1.53gm/cc.
5. Red mud's permeability coefficient is 5.786e-7cm/s, indicating extremely poor permeability. Road embankments, earthen dams, and other structures can be built with low-permeable materials.
6. We may utilize the RM as a pavement material along the village side since its CBR value, when saturated, is 4.2%, which is higher than the 3%.
7. The triaxial test yielded a cohesive strength of 0.123 kg/cm^2 and an angle of shear resistance of 26.80. Compared to the traditional clay material, the red mud has a greater strength value.
8. Numerous possible applications for red mud have been examined, but there is currently no practical, cost-effective, or ecologically acceptable way to use significant amounts of red mud.
9. Research and development are urgently needed to examine the metal speciation and changes related to the reuse of red mud in construction and wet storage of RM in ponds.

5. FUTURE SCOPE

All testing in this paper are conducted on red mud that has not been stabilized. The results of these studies indicate that red mud may be utilized for a variety of geotechnical applications. In the future, the red mud can also be stabilized by adding fly ash, gypsum, and lime.

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