Development of Clay Tiles Based on Novel Materials from Red Mud: A Case Study Analysis

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***Abstract* -Bayer's Process for the production of alumina has led to an insoluble waste product red mud which is generated after bauxite digestion with sodium hydroxide at elevated temperature and pressure. This case study reports aims to compile studies done on the addition of red mud into the clay tiles manufacturing. Red mud being an industrial waste with potent threat needs to be recycled for its disposal needs. the studies reported here move in the same fashion of initial raw materials and testing followed by fabrication and tests results complication. This report investigates the proportions of red mud used and a general flow cycle of the process in the fabrication. It was finalized from all the studies that addition of red mud is a viable and beneficial option for both tiles and the sustainability issues.**

Key words: Red mud, clay tiles, manufacturing, mineralogy, properties

A. INTRODUCTION

Environmental contamination due to solid waste mismanagement is a global issue. Open dumping and open burning are the main implemented waste treatment and final disposal systems, mainly visible in low-income countries. General increase in accumulation of unmanaged industrial waste in the world has been a major concern. These untreated wastes create different problems with climate change by increasing a number of greenhouse gases. Besides this, the use of fossil fuels also contributing the effect on greenhouse gases (GHG) emission. Uncontrolled disposal generates serious heavy metals pollution occurring in the water, soil, and plants, open burning is cause of CO, CO_2, SO, NO, PM10 and other pollutant emissions that affect the atmosphere, waste picking within open dump sites pose to serious health risk people working on these areas and cause environmental threat. On such environmentally impactful waste material is red mud.

Red mud is a byproduct produced in the process of extraction of alumina from bauxite. The process is called Bayer's Process. Its insoluble product and is generated after bauxite digestion with sodium hydroxide at elevated temperature and pressure 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 is produced which is 6.25% of world's total digestion with sodium hydroxide at elevated temperature and pressure. It is a mixture of compounds originally present in the parent mineral bauxite and of compounds formed or introduced during the Bayer cycle. It is disposed as slurry having a solid concentration in the range of 10-30%, pH in the range of 10-13 and high ionic strength. Red mud contains much aluminum and iron and also contains rare metals such as scandium, titanium, and vanadium. The red mud produced from different processes has big difference in respect of appearance and microstructure, so that different red muds have their physical and mechanical properties. The environmental impacts caused by red mud are many. Ground water pollution-when the red mud gets mix with water. Alkali seepage in to underground water-Underground water resources such as wells, aquifer may get polluted. Alkaline air born dust fly with air and effects on transpiration process of plant which result in reduction of plant life. Land disposal changes the property of soil and result in lesser fertility. With all these the need for proper disposal of red mud is crucial. Studies on innovative reuse of the waste is a necessity.

An effective way to deal with this increasing waste is to use this waste for sustainable construction of roads, buildings etc. Construction field is a prominent field in handling this waste to reuse them as construction materials. Clays and clay minerals are very important industrial minerals. There are several documented industrial applications of clay materials. The physical and chemical properties of the clay minerals determine its use as an industrial material, because applications of the clay minerals depend on their compositions, structures and physical properties. Ceramic products are produced from natural materials containing a high proportion of clay minerals. Inclusion of red mud into the fabrication of clay and ceramic tiles is studied in this report. Tiles are a conventional part of the construction industry. In the present scenario of finding sustainable alternatives, innovations in tiles manufacturing are profound. Proper combinations and unifications of the waste into the well-known utilities of the human life can prove to be very beneficial. This report aims to fabricate a review on the manufacturing of clay tiles using various consolidation of red mud. A case study of various previous results is formulated in this report.

B. MATERIALSAND METHODOLOGY

The basic materials used for all the experiments are clay and red mud. Regular clay or a mixture of kaolin, quartz

and Na feldspar is also used. Based on the red mud available the formulation used in the literatures are different from each other. 3 sets of combinations are studied in this article.

i. addition of red mud in 10,20,30% with rest proportion as clay
ii. addition of four different sources of red mud in 40% along with quartz, talc and flint lay
iii. addition of red mud in 65.8- 70% along with 0-6% ammonium molybdate and kaolin

The initial process of the fabrication is homogenization of the raw materials. The raw materials were thoroughly dried and powdered in required size. For all the casesthe raw materials were then mixed in a moisture content of 6-8% and made into rectangular or cylindrical or prismatic shaped tiles each dimension different under a hydraulic press with 25-40 MPa load. The fabricated tiles are then sintered under high temperatures, nearly 950- 1200^C with soaking at the highest temperature for about 2 hr.

The elementary chemical composition of all the raw materials were done initially under x-ray fluorescence (XRF). The table 1 shows the list of the highest occurring constituents of the raw materials tested in the cases studied. The crystalline phases were determined by x-ray diffraction method (XRD). Thermal analysis of the raw materials especially red mud was done by thermo-gravimetric analysis (TGA). The microstructure of specimen was calculated by scanning electron microscope (SEM). radioactivity of red mud was also analyzed by gamma spectrometer in one of the cases.

The sintered samples were then subjected to tests for finding the mechanical properties. Archimedes principle was mainly adopted to find the water absorption and bulk density of the tile's samples. The XRD f the sintered samples were also found at higher temperatures. The specimens were tested for its flexural strength mainly by 3-point bending test. Unconfined compression test was also conducted on the samples. The firing shrinkage of the samples were also tabulated since there would be a dimension change after firing. To find the environmental impacts, leaching tests was also done on the crushed specimens after the tests were done.

C. RESULTS

The results of XRF of the red mud in all the cases showed a composition of Sio2, Fe2O3, Al2O3, CaO, TiO2 etc. the clay used had a higher percentage of kaolin. The XDR results shows the diffraction peaks and curves thereby indicating which specimen would have better crystallization properties. due to the high-water retention capacity of red mud, variations in test results were prominent in the study. Also sintering of the samples in most cases led to the improvement in the features of the tiles.

In the analysis of addition of 10-30% red mud in clay showed that due to the water retaining character of red mud addition of higher amount of red mud would lead to a reduction in the density of the specimen. This reduction was fortunately compensated by increasing the sintering temperatures from 950 to 1015^C. same was the result with flexural strength and compressive strength. The increased temperatures would lead to the mullite crystallization and enhancing of the mechanical strengths of the specimen tiles. Densification of the specimen at sintering improved the water absorption and porosity of higher proportions of red mud added specimens. The specimen with better results at a lesser sintering temperature was considered to be apt. Scanning electron microscope results showed the morphology of the tiles. the addition of red mud showed differences in the homogeneity of the tiles. The environmental impacts of the specimens were also tested by either the raw materials analysis of radioactive elements or trace elements or the tested samples were crushed and tested for its constituents and checked for the composition. In all the cases the test results showed that the composition of the specimens proved no threat to the environment.

D. CONCLUSIONS

From all the cases studies it can be concluded that the addition of red mud in the ceramic industry is surely a worthwhile alternative from increasing the properties or being in the acceptable industrial usage range. the addition of red mud into clay in different proportions led to an increased mechanical property in all the studies done. The flexural and compressive strength of the tiles tested improved at a higher sintering temperature. The optimum temperature range of the tiles is notes as between 1015-1180^C. the initial tests like XRD and XRF shows the range of crystallization of the raw materials constituents. The case study report thus verifies the suitability of red mud in the usage.

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