

# Use of Red mud as partial replacement of cement: A Review

Bibhuti Aryal<sup>1</sup>, Vanita Aggrawal<sup>2</sup>

<sup>1</sup>M.Tech, Research Scholar, Maharishi Markandeshwar Engineering College, Mullana, India

<sup>2</sup>Professor and Head, Civil Engineering Department, MMEC, Mullana, India

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## ABSTRACT

A large variation in the cement and concrete in dusty needs to be made to deduct the environmental pollution, especially CO<sub>2</sub>, in order to gain consistent steps towards sustainable development. Manufacturing of concrete has been increasing in the past decades and this is now one of the biggest concerns of researchers who follow a sustainable development proposal. The consumption of natural resources will also be reduced by the use of waste material during the manufacturing of concrete. On the other hand, red mud (RM), granite (GP), and marble (MP) waste powders, whose disposal has adverse environmental effects, have become environmental concerns in industrial areas. In highlighting of these problems, employing alternatives to benefit from such precious local waste materials, rich in silica, alumina, and ferric oxide, can be a great help to the environment. Red mud is a waste product originated by the Bayer process conventionally used to generate alumina from bauxite all over the world. The purpose, of the current analysis work was to look over the suitability of replacing the Portland cement by red mud. Effect of red mud on environment as well as on mechanical properties of concrete is also reviewed. During replacement of cement by red mud it demonstrates to be cheaper since red mud is a outgrowth of alumina industry use to accessible at free in nature. Therefore, after the current study red mud may be utilized in partial replacement of cement.

**Keywords:** Bayer Process, Red mud, Cement, Concrete, Sustainable

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## INTRODUCTION

Aluminum is having lightweight, high strength and may be reuse for constructional material. It plays an significant role in social promotion and used in many other factor such as:- transportation, food and beverage packaging, infrastructure, building and construction, electronics and electrification, aerospace and defense (Ramesh et al; 2013). Aluminum is known as third largest element, which is not originate in free state, but used to combine along more admixtures. Bauxite ore contain highest amount of alumina including minerals like silica, iron oxide, and other impurities in small quantity. Now days, aluminum plants are being used rapidly throughout the world, due to its increasing demand it may be obtained as a replacement of steel and other materials (Alam et al; 2017). In aluminum industries,

Red Mud (Fig 1) is one of the byproduct highly produced during refining of alumina in Bayer's process. In the Bayer's process, the insoluble product generated after bauxite digestion with high concentration of sodium hydroxide (NaOH) solution is used at high temperature and pressure to produce alumina (Bayat et al 2018). Aluminum has been considered to be 5th largest producer of bauxite in the world. Mostly, the aluminum industries are located closer to the sea. To dispose off the red mud produced while extracting aluminum. Where Red mud is that residue which is in the form of slurry is deposit off and seared in the wide decompose area. While they are being directly disposed into the sea thereby having an unfavorable effect on the aquatic plants and animals. For the manufacturing of tons of alumina, it may be estimated about 1-2.5 tone of red mud is generated (Bavani et al; 2018). In India, 4 million of red mud is manufactured yearly. At present scenario, the annual production of red mud is about 120 million tons globally, which may not be decomposed off or reused satisfactorily. However, the disposing activities are becoming expensive and difficult. India has been contributing nearly 6.25% of the annual red mud manufacturing worldwide that consists of solid and metallic oxide defilement (Bavani et al; 2018). While dumping this red mud, it pollutes the soil and water because red mud obtains some harmful particles and

acquires precious land. Red mud also takes cementitious behavior, which can be used in many construction practices by partially replacing cement. Replacement of cement by red mud proves to be reasonable since it is a outgrowth of alumina industry and is available with free in nature. Some researcher has found that the red mud is potential used in brick manufacturing and ceramic items (Dodoo-Arhrin et al; 2013 and Yang et al 2008). Red mud has a high alkalinity due to which it becomes a toxic waste product generating the issue to surrounding and ground water pollution. These global concerns have attracted considerable attention for the investigation in feasibility of using red mud in various civil engineering fields. Red mud decreases the permeability thereby augmenting increase in the strength of the concrete. Red mud saves from corrosion in reinforcement and it also behave as a good binding material (Bavani et al 2018). Therefore, this red mud may be used as a partial replacement of cement in mortar and concrete mixture.



Fig: 1 Red Mud

### PRODUCTION OF RED MUD

China has more than 50% of production of aluminum whereas India covers about 5% of the global smelter production. Aluminum industries are being set up day by day which in result, the more the alumina the more will be production of red mud. As per the global result: China covers 55% of aluminum production similarly Russia and Iceland produces 6% each, Canada produces 5%, United Arab Emirate produces 4%, Australia produces 3%, Norway produces 2 % whereas USA, Bahrain, Brazil, and India produces 1% each and rest of other countries produces 13% of aluminum all together.

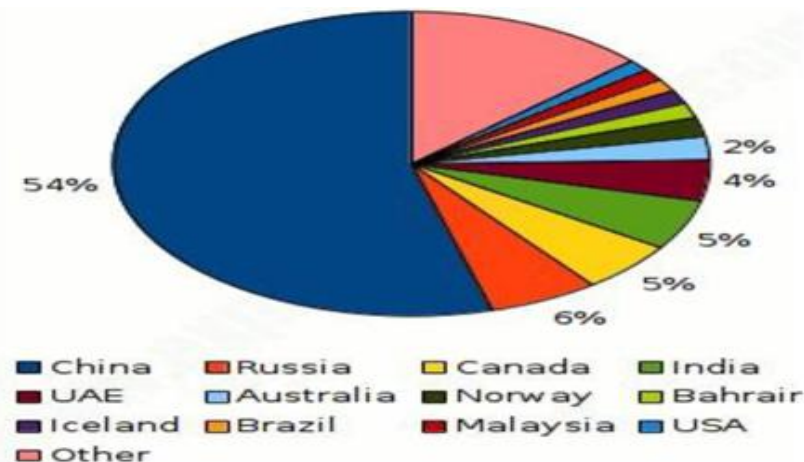


Fig.2 Pie chart indicating scenario of percentage of production of Aluminium in the world

### PROPERTIES OF RED MUD

Every matter available in this nature exists with some properties in it. Similarly, red mud also possesses some kind of properties in its nature they are listed below:-

**Physical properties:-** The colour of red mud is in dark red, odour of red mud is Pungent, Texture of red mud is Fine, Specific Gravity of red mud lies between 1.96-3.25, pH value of red is 10.4, fineness of red mud lies between 1000 to 3000 cm<sup>2</sup>/gm. The practical size of red mud is 14.8 μ m. Red mud is basic in nature.

**Chemical properties:-** The chemical properties of red mud such as iron oxide ( $\text{Fe}_2\text{O}_3$ ) ranges from 30-60%,  $\text{Al}_2\text{O}_3$  ranges from 10-20%,  $\text{SiO}_2$  ranges from 3-50%,  $\text{Na}_2\text{O}$  ranges from 2-10%,  $\text{CaO}$  ranges from 2-8% and  $\text{TiO}_2$  ranges from Trace-25% respectively. Hence, from the study we found that there is less percentage of  $\text{CaO}$  therefore it has no cementitious properties but when we mix it with water and cement, it shows cementitious properties and percentage of Silica available in the red mud gives strength to the cementitious mixture. Some more properties comes under chemical properties of red mud such as  $\text{MgO}$  ranges from 1.13-1.7,  $\text{K}_2\text{O}$  ranges from 0.1-0.73 and  $\text{MnO}$  ranges from 0.0078-0.1.

### RED MUD USED IN CEMENT PRODUCTION

Throughout the world different researchers has been studied the manufacturing of red mud by doing it practically. Over all, two million tons of red mud is used in cement manufacture (Agrawal et al 2004). In Japan, while manufacturing of cement the raw material is taken as red mud with other raw material such as clay and lime stone etc. The several materials like red mud also reach with the specifications of Standard in process of developing cement.

In 1997, the new kind of cements is developed by using different variability of red mud, lime, bauxite and gypsum. The compressive strength of this cements were found approximate to OPC. The cement assembles with 50% lime, 30% red mud and 20% bauxite is about  $10\text{N/mm}^2$  due to its 28 days of compressive strength. The manufacturing of this cement has optimum firing calenture and firing schedule was 1300oc and 1.5 hours approximately. The highest compressive strength of  $25\text{N/mm}^2$  is reach taking 47.5% of lime, 7.5% of gypsum, 40% red mud and 5% bauxite. The manufacturing of this cement has optimum firing calenture and firing schedule is  $1250^\circ\text{C}$  and 1 hour approximately.

Cement production reduces the burning temperature of clinker by adding of red mud about 3.5% with its raw material (Tsakiridis et al 2004 and Jaspal Singh). Mineralogically, red mud based clinker is corresponding to Portland cement. The 90 days compressive strength of red mud form clinker is about  $55\text{N/mm}^2$ , which is excessive than the Portland clinker.

### EFFECTS OF RED MUD ON ENVIRONMENT

Numerous researchers have assessed the impact of red mud mixing with agricultural soils. A further issue in both streams and the affected soil environments is potential for the long-term cycling of metals and metalloids in the soil-water environment due to anion-exchange reactions. Here, are some of the effects of red mud on environment as mentioned below-

- Red mud used to pollute the water resources such as:- river, stream, seas etc. i.e when we mix the red mud in water it pollutes the water resources.
- Due to toxicants presence in red mud, underground water resources like:- wells, aquifer gets polluted and contaminants.
- Due to hazardous exposure of human population the Aluminum products should be minimized so that disaster may not take place and environment can become a sustainable.
- While dumping the red mud into the ground, it used to affects the fertility of the soil, which in result reduces the life of plants and other living organism.
- Effects on respiration process of animals and plants, which may lead the air borne disease and may affect their life also.
- The red mud disposed off in land it used to reduce the fertility of the land and affects in agriculture.
- The red mud covers the large area and use to loss the land value, due to presence of toxic product.

### EFFECTS OF RED MUD ON CONCRETE PROPERTIES

Experimental study shows that use of red mud as partial replacement of cement has significant effect on mechanical properties of cement concrete as shown in Table 1 and Table 2. Following major observations are given below:

- It is found that in M30 Grade of concrete the percentage of red mud 0-5% affects the compressive strength  $0.12\text{N/mm}^2$ ; similarly, it is also found that in same grade of concrete the percentage of red mud 0-5% affects the split tensile strength in terms of  $0.059\text{N/mm}^2$ .
- Red mud only may affect the concrete workability but can be upgrade by adding some super plasticizers.
- Due to the airy of neutralized red mud and final practical of mud decreases the initial setting time by 5%-10%.
- Utilization of red mud in structural work may help in cost reduction of whole structural projects.

**Table 1. Average compressive strength (N/mm<sup>2</sup>) (Gowsalya.R and Bhagyalakshmi, 2015)**

Grade of concrete	Used % of red mud	Compressive strength (N/mm <sup>2</sup> )
M 30	0	33.3
	5	33.42
	10	34.15
	15	36.12
	20	38.5
	25	35.32

**Table 2:- Average Split Tensile Test (N/mm<sup>2</sup>) (Gowsalya. R and Bhagyalakshmi. A 2015)**

Grade of concrete	Used % of red mud	Split tensile strength (N/mm <sup>2</sup> )
M 30	0	45.31
	5	45.09
	10	46.01
	15	46.87
	20	48.39
	25	46.37

## CONCLUSION

From the above study on red mud, the following important points are concluded:

- Replacement of cement with Red mud, decreases the production of cement resulting it into saving energy and cost and credit to CO<sub>2</sub> emission.
- Results of studies, conducted by different researchers show the optimum dosage of replacement of cement with red mud is 20% after percentage the strength properties, reduces.
- Properties of red mud are similar to that of cement, thus it can be effectively used as binder in concrete which results in less production of cement and subsequent decreases CO<sub>2</sub> emissions.
- Red mud being industrial solid waste, if used can help to reduce the disposal problems and reduce environment threats.
- The use of waste material can help to construct structure with low cost.
- The use of red mud helps to save the resources aggregate for production of cement followed by conservation of raw material which results into sustainable work.
- The production of red mud in India is comparatively less than other countries in the world so the issue of surface and ground water pollution can be controlled in large amount.
- There is a vast future scope for utilization of red mud in structural as well as civil engineering projects.

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