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Suitability and Utilization of Neutralized Red Mud and Hydrated Lime as a Partial Replacement of Cement in Concrete

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Abstract: ***The aim of present work is to check the suitability and utilization of neutralized red mud and hydrated lime as a partial replacement of Portland cement in concrete. To develop concrete mix design with industrial waste red mud and hydrated lime. the workability of the concrete, compressive strength, Split tensile strength of the concrete and flexural strength of the concrete is determined and comparative study is done.***

I. INTRODUCTION

Aluminum plants are being set up rapidly throughout the world due to the increasing demand of aluminum as it is being used as a replacement of steel and other materials (Alam et al 2017). In Aluminum industry, red mud is one of the byproducts obtained when alumina is extracted from the bauxite ore through the Bayer process. To digest the bauxite ore, high concentration of sodium hydroxide (NaOH) solution is used at high temperature and pressure (Bayat et al 2018). India is considered to be 5th largest producer of bauxite which is the primary ore of aluminum in the world. In our country, the main producers of aluminum being National Aluminum Company (NALCO), Bharat Aluminum Company (BALCO), Hindustan Aluminum Company (HINDALCO) and Sesa Sterlite (now renamed as Vedanta). Mostly, the aluminum industries located closer to the sea dispose off the red mud into the sea thereby having an unfavorable effect on the aquatic plants and animals. In other cases, the residue which is in the form of slurry that is red mud (having a high solid concentration of 30-60% with a high ionic strength) is disposed off and dried in the large disposal area. Depending on the amount of bauxite and the type of process adopted in Aluminum industry, 1.0 – 2.5 tons of red mud is generated for every one ton of alumina produced (Bavani et al 2018). At present, 120 million tons of red mud is generated worldwide annually which is not being disposed off or recycled satisfactorily. Moreover, the disposing activities are becoming expensive and difficult. India contributes approximately 6.25% of the global red mud production that categorically consists of solid and metallic oxide impurities (Bavani et al 2018). Some researchers have found the potential use of red mud in the brick production and ceramic products (Dodoo-Arhin et al 2013 and Yang et al 2008). Red mud can also be used as catalyst and as adsorbent for removal of some valuable metals such as titanium and iron which can be recovered from the red mud (Kurtoğlu and Uzun 2016, Liu and Li 2015). Red mud has a high alkalinity (pH ranging from 9 to 14) due to which it becomes a hazardous waste material creating the problem of surface and ground water pollution. These environmental concerns have drawn considerable attention to investigating the feasibility of using red mud in various civil engineering fields. Red mud reduces the permeability thereby augmenting increase in the strength of the concrete. Red mud prevents the corrosion of reinforcement and it also acts as a good binding material (Bavani et al 2018). Therefore, it can be used as a partial replacement of cement in mortar and concrete. Different researchers utilized the red mud in their studies to increase the strength of concrete and cement-based materials and to improve the durability characteristics besides reduction in cost of concrete.

Production of aluminum in China is over 50% while India accounts for about 5% of global melt production. Now, more and more aluminum industries are being set up resulting in more alumina production which is also increasing the production of red mud. According to the Pie chart, China participates in the production of Aluminum worldwide by more than 50% and half of our country is almost 5% of global production.

II. LITERATURE REVIEW

Pujar et al (2014) evaluated the use of red and unwashed red mud on concrete to change the cement portion from 0% to 20% at intervals of 2%. Various tests such as compressive strength, flexibility, solid separation strength, shear strength, water absorption and efficiency are performed to determine concrete properties. It was found that shear strength, compressive strength, flexibility and split strength increased with an increase of washed red mud up to 8% and unwashed red mud up to 2%, after which a decrease in strength was observed. In addition, it was noted that water absorption and absorption decreased as washed red mud was increased to 8% and unwashed red mud was up to 2%. The strength, performance and wetness of the washed red mud was higher than the unwashed red mud.

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Rathod et al (2014) extract 5%, 10%, 15%, 20%, 25%, 30%, 35% and 40% cement mixed with mortar red that takes control of 0%. It was noted that the compressive strength and resilience decreased with the increase in the amount of red mud. A good percentage of red mud to be replaced in cement is recommended to be 25%. Metilda et al (2015) evaluated the use of red mud in concrete when cement was replaced by red mud by 0% to 25% at intervals of 5%. Based on the experimental study, it was noted that the compressive strength, strength and flexibility increased with an increase in the percentage of red mud up to 15% but beyond 15%, there was a decrease in strength. Therefore, it is recommended that cement mortar be replaced with up to 15% red cement.

Shinge and Pendhari (2015) slightly modified cement with red mud at different rates of 0%, 5%, 10%, 15% and 20%. It was found that the compression force decreased with the percentage of red mud. Also, it was noted that strength and flexibility increased with an increase in the percentage of red mud. On the basis of the experimental study, it was suggested that 10 percent of the red mud could be used effectively to replace part of the cement without compromising the compressive strength.

Shinge et al (2015) combined the use of red mud and ash husk ash in cement-based materials (mud). The estimates of red mud and ash husk used were 5%, 10%, 15% and 20%. The compressive strength in 0%, 5%, 10%, 15% and 20% red mud was 36.72 N / mm2, 36.10 N / mm2, 34.33 N / mm2, 30.33 N / mm2 and 25.25 N / mm2 while the dynamic strength was 3.00 MPa, 3.19 MPa, 3.43 MPa, 3.51 MPa, 3.66 MPa for 28 days which means that the compressive strength of the red mud was reduced while the strength of the force increased by half of the red mud.

Yamuna (2015) investigated the use of red mud and quarry dust in cement and concrete mortar. Cement and fine adhesives were replaced with red mud and quarry dust. Different concentrations of red mud were used such as 0%, 5%, 10%, 15%, 20%, 25% and 30% cement mortar. From the point of view of pressure, a high percentage of red mud in cement mortar is recommended as 20%. To keep the red mud as low as 20% and to exchange positive aggregates with quarry dust in the proportions of 0%, 10%, 20%, 30%, 40%, 50% and 60%, tests were performed to determine the strength of the solid separation. The strength of the separating force rises up to 40% of the quarry dust and falls.

Mahin Sha et al (2016) studied the effect of red mud concrete on performance, compressive strength and durability. Concentration rates for red cement are about 0% to 25% at intervals of 5%. Experimental studies have shown that the compressive strength and durability decrease with an increase in the percentage of red mud while the performance of concrete increases with an increase in the percentage of red mud. Therefore, good use of red mud instead of cement was recommended as 20%.

Kumar et al (2016) investigated the effect of red mud on cement mortar over the effect of red mud and quarry dust for cement and sand compaction. First, cement was replaced with red mud at various levels ranging from 0 to 30% at a rate of 5%. It was found that the compressive strength of cement mortar increased by up to 20% followed by a subsequent decline. Therefore, a good percentage of red mud was 20% when the cement was partially replaced. Second, this improved percentage of red mud combined with the variable percentage of quarry dust was used to change the sand portion (from 0 to 60% with a 10% increase). It was observed that the compressive strength and the separated strength of the rust rise up to 40% of the quarry dust and are reduced. It can therefore be concluded that a large percentage of red mud was 20% cement while a high percentage of quarry dust was 40% in concrete.

III. MATERIAL USED

1) *Cement:* The use of cement for experimental studies was Ultra tech cement 43 grade OPC as specified in Indian Standard Code IS: 8112-1989. The gravitational force of cement was 3.10.

Table: Physical Properties of Cement

Sr. No.	Characteristics	Experimental value	Specified value as per IS:8112- 1989
1	Consistency of cement (%)	33%	---
2	Specific gravity	3.10	3.15
3	Initial setting time (minutes)	63	>30 As Per IS 4031-1968
4	Final setting time (minutes)	495	<600 As per IS 4031-1968
5	Compressive strength (N/mm^2) 3days 7days 28days	 20.45 23.87 33.50	 >23 >33 >43

6	Soundness (mm)	1.00	10
7	Fineness of Cement	5.5%	10% As Per IS 269-1976

2) *Coarse Aggregates:* The coarse aggregate used were a mixture of two locally available crushed stone of 20 mm and 10 mm size in 70:30 proportion. Coarse aggregate of maximum size 20mm and minimum 10 mm is used throughout the concrete. The specific gravity of coarse aggregate is 3.09.
3) *Fine Aggregates:* Fine aggregate is used in this experimental study for concrete is river sand conforming to zone- II. The specific gravity of fine aggregates 2.65.
4) *Red Mud:* The conventional method of disposal of red mud in ponds has often adverse environmental impacts as during monsoons, the waste may be carried by run-off to the surface water courses and as a result of leaching may cause contamination of ground water: Further disposal of large quantities of Red mud dumped, poses increasing problems of storage occupying a lot of space. Over the years, many attempts have been made to find a use for red mud, in this paper the attempt is made to check the effectiveness of red mud at 5% 10%, 15%, 20%, 25% over Portland cement by partial replacement of cement in concrete. Generally Fineness of red mud is varies in between 1000-3000 cm2/gm. We collected red mud from BALCO, Korba, Chhattisgarh (INDIA).In our study we have taken red mud passing through 300 micron I.S. Sieve.

Its PH is varies in between 10.5 to 12.5 hence alkaline in nature.



Fig Image of Red Mud procured from Balco, Korba

Table Chemical Composition of Red Mud

S.No.	COMPOUND	WEIGHT[%]
1.	Al_2O_3	14.14
2.	SiO_2	11.53
3.	Fe_2O_3	48.50
4.	TiO_2	5.42
5.	CaO	3.96
6.	V_2O_5	0.116
7.	MgO	0.049
8.	ZnO	0.027
9.	Na_2O	7.50
10.	P_2O_5	0.297
11.	MnO	0.17
12.	K_2O	0.058
13.	L.O.I	7.25

5) *Water:* Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalis, salts and sugar, organic substances that may be deleterious to concrete. As per IS 456- 2000 Potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly, potable tap water was used for the preparation of all concrete specimens.

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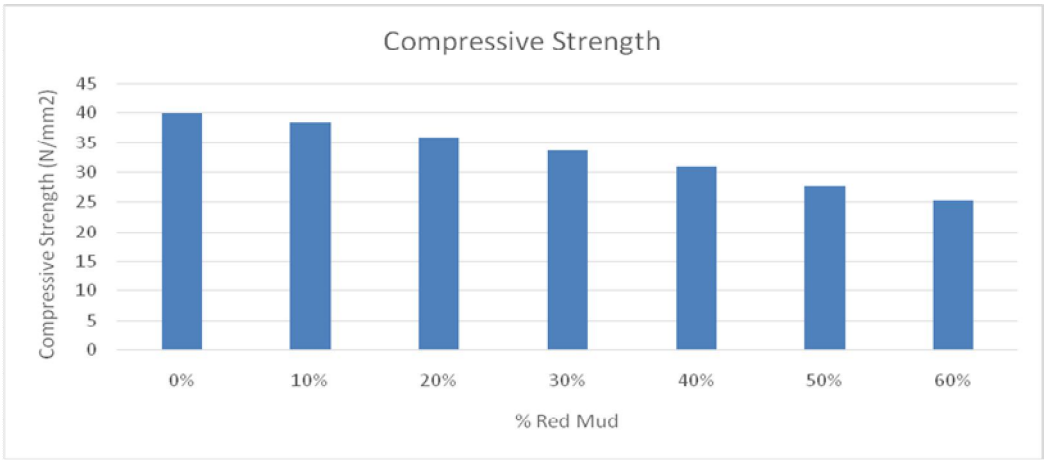
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IV. METHODOLOGY

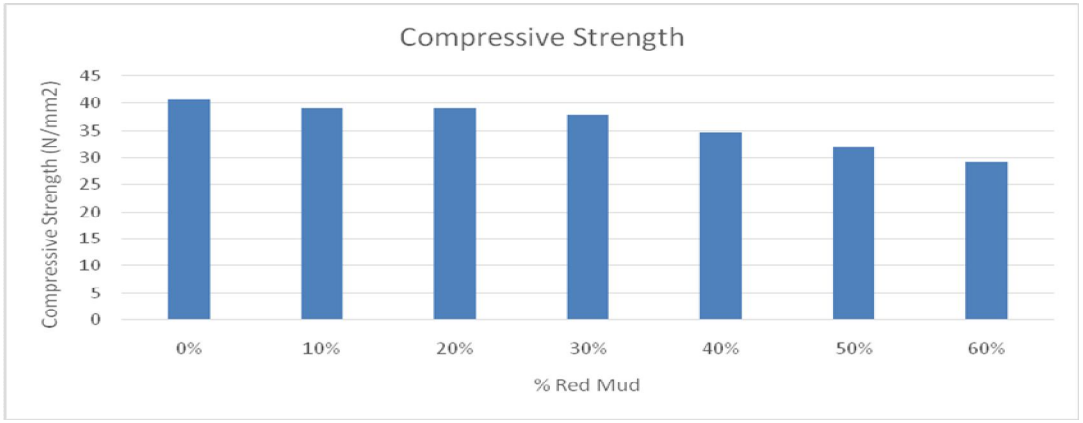
New concrete structures such as the slump cone test and the element strength test have been investigated. Solid concrete structures such as pressure, strong dividing forces, flexible strength are determined. The rate of conversion of red mud used as 0%, 10%, 20%, 30%, 40%, 50% and 60% as concrete with 5% hydrated lime. Comparisons of the effects of hydrated and external lime have been made.

V. RESULTS

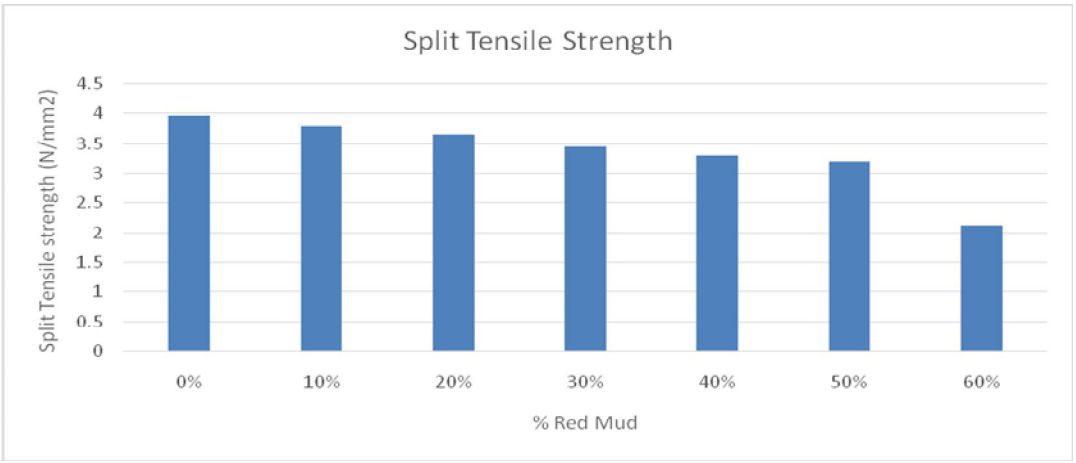
Compressive strength of samples without hydrated lime after 28days



Compressive strength of samples with 5%hydrated lime after 28 days

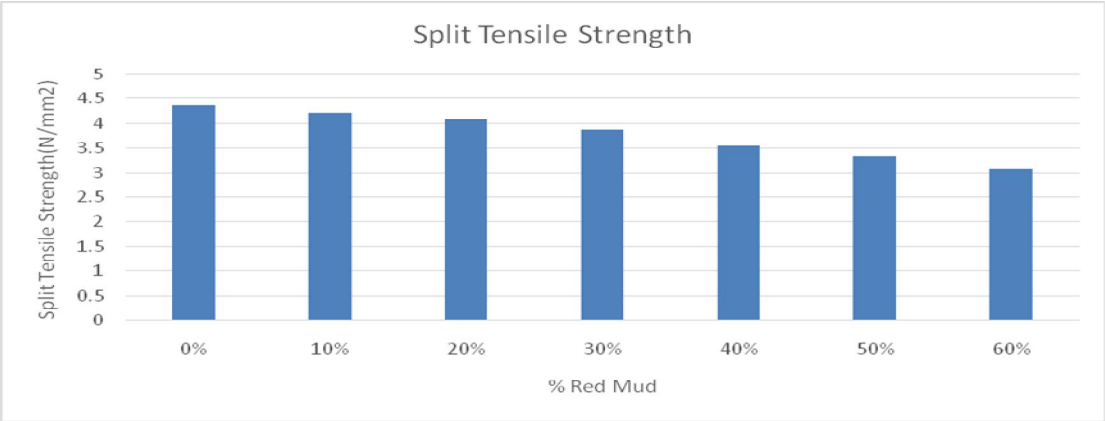


Split tensile strength of samples without hydrated lime after 28 days



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Split tensile strength of samples with 5% hydrated lime after 28 days

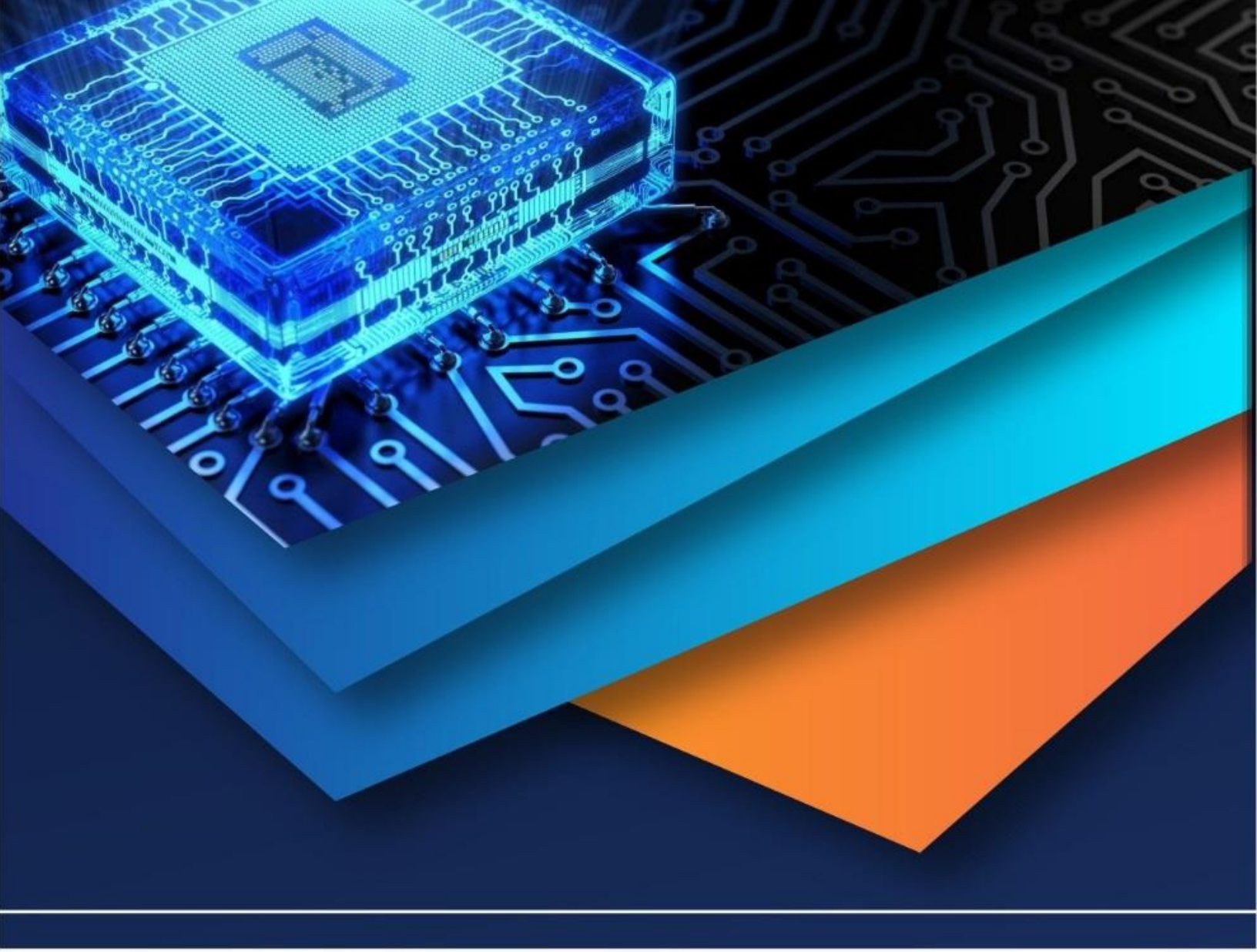


VI. CONCLUSIONS

1) The use of red mud and liquid lime instead of part gives us the option to use industrial waste.
2) Effectively, testing of concrete degradation capacity increases with a percentage of red mud from 0% to 60% in both liquid and non-aqueous.
3) The amount of compaction factor increases with an increase in the percentage of red mud from 0% to 60% in both wet or non-liquid lime.
4) The highest quality compression was obtained in 10% red mud for 7 days and 28 days for healing
5) With more than 10% change the concrete compression strength decreases.
6) Total total separation and flexibility was observed in 10% red mud for 7 days and 28 days for healing.
7) Beyond 10% the divided strength of the divided concrete decreased.

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