Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 10, No. 1, October : 2023

EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENT BY RED MUD IN CONCRETE

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ABSTRACT
The disposal of enormous quantities of red mud, a solid waste generated in aluminium factories around the world, poses an increasing storage, land cost and availability, and pollution challenge. Because of the complicated physio-chemical features of red mud, designers face a difficult problem in determining the most cost-effective and safe disposal method for red mud. The construction sector is in full swing as a result of the government of India's industrialization, infrastructure development, and soft housing policy, which has resulted in a phenomenal growth in the utilisation of cement and concrete for various construction activities in a relatively short period of time. The similar rate is anticipated to continue in the coming decade, posing a hazard to the environment. The availability of raw materials required for the production of cement and concrete is limited. The availability of raw materials required for the production of cement and concrete is limited. This growing demand will result in rapid depletion of natural resources and a significant threat to the environment. To solve this problem, it is critical to use industrial waste materials and byproducts generated during cement manufacturing and concrete construction. The purpose of this paper is to evaluate the effectiveness of neutralised red mud as a partial replacement for Portland cement.

Key Words: - Red Mud, Beyer's process, Compressive strength

1.1 INTRODUCTION

Industrialization and urbanization are the two world wide phenomena. Though these are the necessity of the society and are mostly in evitable, one has to look into their negative impacts on the global environment and social life. The major ill effect of these global process is the production of large quantities of industrial wastes and the problems related with their safe management and disposal. Second problem is the scarcity of land, materials and resources for ongoing developmental activities , including infrastructure.Aluminum is a great weight, high strength and recyclable structural metal. It plays an important role in social progress and has a pivotal contribution in transportation, food and beverage packaging, infrastructure , building and construction, electronics and electrification , aerospace and defense. It is the third abundant element in the earth's crust and is not found in the free state but in combined form with other compounds. The commercially mined aluminum ore is bauxite, as it has the highest content of alumina with minerals like silica, iron oxide, and other impurities in minor or trace amount. The primary aluminium production process consists of three stages: mining of bauxite, followed by refining of bauxite to alumina by the Bayer process and finally smelting of alumina to aluminium. In the Bayer process, the insoluble product generated after bauxite digestion with sodium hydroxide at elevated temperature and pressure to produce alumina is known as red mud or bauxite residue. The waste product derives its color and name from ots iron oxide content. As the bauxite has been subjected to sodium hydroxide treatment, the red mud is highly caustic with pH in the range of 10.5-12.5. Bauxite posing a very serious and alarming environmental problem.cement in general sense of the word, can be described as a materials with an adhesive and cohesive properties which make it capable of bonding mineral fragments into a compact mass. This definition encompasses a large variety of cementing material. For constructional purposes the meaning of the term cement is restricted to the bonding materials used with stones, stand, bricks, blocks etc. cement is the most important materials in structural constructions as it is used at different stages of construction in the form of mortar or concrete.World consumption of cement is forecast to continue to increase throughout the next 15y ears, taking the annual volume up from the 2250 MT of 2005 to around 3130 MT by 2015 and 3560 MT by 2020, representing overall forward expansion of approximately 56% according to the " GLOBAL CEMENT to 2020", world production and consumption of cement approximated 2250 MT in 2005 this level representing an increase of approximately 5. 75 % (124 MT) on the previous year and a continuation of the annual underlying expansion which has seen year- on -year growth in almost every year since the 1970s.

1.2. Types Of Industrial Wastes

The Nation's solid wastes are increasing, posing a severe threat to the environment. The various solid wastes are:-

1.2.1 :- Red Mud

The Red Mud is one of the major solid wastes coming from Bayer process of alumina production. At present about 3 million tones of red mud is generated annually, which is not being disposed or recycles satisfactorily. 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.

1.2.2 :- Fly Ash

About 72% of power generated in India is from Thermal power stations. It has been estimated that about 30 million tones of Fly ash is produced per year by 60 thermal plants located in different parts of country. The common environmental pollution problems created by disposal of Fly ash, besides air and water pollution are wastages of large tracts of land which otherwise could be utilized for useful purposes. It has been estimated that a one thousand mega watt station, using coal of calorific value of 35oo Kilo cal per kg and ash content of 40-50 percent for an operational period of 30 years requires about 500 acres of land.

1.2.3 :- Phosphogypsum

Phosphogypsum is the waste generated by the phosphoric acid, ammonium phosphate and hydrofluoric acid manufacturing plants. There is an accumulation stock or more than 10 million tones of Phosphogypsum at different at different plant sites. The fluoride content of gypsum generated is 0.7-1.5% which is the source of land and water pollution.

1.2.4 :- Steel and furnace slags

About 35 million tones of steel and blast furnace slags are produced in the country during manufacture of iron and steel. It has been estimated that the quantity of slags will increase to about 60 million tones around 2000. The large quantity of slags generated in plants is dumped on land nearby, which not only results in wastages of land but also causes surface and ground water pollution.

1.3 :- Materials Used

1.3.1 :- Cement

Cement is an extremely ground material having adhesive and cohesive properties, which provide a binding medium for the discrete ingredients. It is a well known building material and has occupied in indispensable place in construction works. There are a variety of cements available in the market and each type is used under certain conditions due to its special properties. A mixture of cement and sand when mixed with water to form a paste is known as cement mortar, where as the composite product obtained by mixing cement, water and an inert matrix of sand and gravel or crushed stone is called cement concrete. The distinguishing property of concrete is its ability to harden under water.

1.3.2 :-Fine aggregate

It is the aggregate most of which passes through a 4.75mm IS sieve and contains only that much coarser material as is permitted by specifications. Sand is generally considered to have a lower size limit of about 0.07mm. According to size the fine aggregate may be described as coarse, medium and fine

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 10, No. 1, October : 2023

sands. Depending upon the particle size distribution, IS:383-1970 has divided the fine aggregate into four grading zones. The grading zone become progressively finer from grading zone I to grading zone IV.

1.3.3 :- Coarse aggregate

The aggregates most of which are retained on the 4.75mm IS sieve and contain only that much of fine material as is permitted by the specifications are termed coarse aggregates. The graded coarse aggregates is described by its normal size i.e 40 mm, 20mm,16 mm and 12.5,, etc. A graded aggregate of normal size 12.5mm means an aggregate most of which passes the 12.5mm IS sieve. Since the aggregates are formed due to natural disintegration of rocks or by artificial crushing of rock or gravel, they derive many of their properties from the parent rocks.

1.3.4 :- Red Mud

The red mud is one of the major solid wastes coming from Bayer process of alumina extraction. At present about 3 Million tones of red mud is generated annually which is not being disposed or recycled satisfactorily. The conventional method of disposal of red mud in pond has often adverse environmental impacts during monsoon. The waste may be carried by run-off to the surface water courses and result of leaching may cause contamination of ground water and also destroy the fertility of soil. Further disposal of large quantities of red mud dumped, posses increasing problems of storage.

1.5:- Objective Of The Work

Basically this paper is based on the dissertation work carried out to overcome the problems created dur exhaustion and obsolescence of raw material required for manufacturing of conventional building material and also minimize the thrust of industrial waste on the environment by utilizing the same in the construction industry.

2:- LITERATURE REVIEW

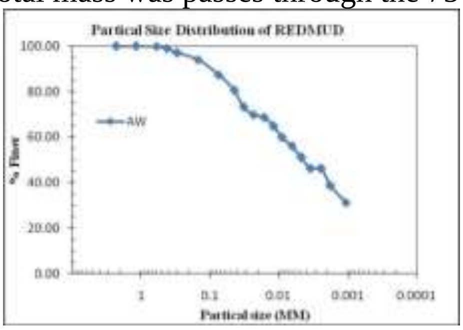
2.1 :- Introduction

The main aim of this experimentation is to find out the effect of addition of red mud, which is a waste product from the aluminium industries, on the properties of concrete. There are several investigations on red mud focused on the characteristics of red mud in both fresh and hardened. Considerable research and development work for the storage, disposal and utilization of red mud is being carried out all over the world. This article provides an overview of the basic characteristics of red mud. The main ways of comprehensive utilization are also summarized. It describes the progress of experimental research and comprehensive utilization. The aim is to provide some valuable information to further address the comprehensive utilization of red mud. There for in this project an attempt have been made to focus the characteristic & performance.

2.2 : Properties of Red Mud 2.2.1: Index Properties

Specific gravity of the red mud has been carried out as per the IS specifications. The experiment was performed from both pycnometer method and density bottle. The specific gravity of the red mud was found to be 3.04.

Particle size distribution of the red mud was carried out as per the IS specifications. The particles passing through 75 micron was collected and allowed to sieve analysis to determine the particle size variation. About 87.32% of the total mass was passes through the 75 micron sieve.



2.2.2 :- Chemical and Mineral Composition Of Red Mud

Red mud is mainly composed of fine particles of mud. Its composition property and phase vary with the origin of the bauxite and the alumina production process, and will change over time when stocked. 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. Tables 2 and 3 list the chemical and mineral compositions of red mud that are produced by the Bayer process [4].

Table 2. Typical composition of red mud

Composition	**Percentage**
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%

2.2.3 Mineralogical Phases:

- Mineralogical phases of red mud are listed below [5]
- Hematite Fe_2O_3
- Goethite FeO(OH)
- Gibbsite $AlOH_3$
- Diaspore AlO(OH)
- Quartz SiO_2
- Cancrinite $(NaAlSiO_4)_6CaCO_3$
- Kaolinite Al_2O_3 $2SiO_2$ $2H_20$
- Calcilte [$CaCO_3$]

2.3 Comprehensive utilization of red mud in construction :

2.3.1 Red mud in cement replacement

Dicalcium silicate in red mud is also one of the main phases in cement clinker, and red mud can play the role of crystallization in the production of cement clinker. Fly ash is mainly composed of SiO_2 and Al_2O_3, thus can be used to absorb the water contained in the red mud and improve the reactive silica content of the cement. Scientists conducted a series of studies into the production of cement using red mud, fly ash, lime and gypsum as raw materials. Use of red mud cement not only reduces the energy consumption of cement production, but also improves the early strength of cement and resistance to sulfate attack [6].

2.3.2. Concrete industry :

Red mud from Birac Alumina Industry, Serbia was tested as a pigment for use in the building material industry 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 of red mud (upon sieving: 0.147 mm up to 4 wt%, 0.058 mm up to
25 wt% and the majority smaller than 10 microns) and a characteristic red colour. Compressive strengths from 14.83 to 27.77 MPa of the blocks that contained red mud between 1 and 32% were considered satisfactory. The reported tests have shown that neutralized, dried, calcined and ground red mud is usable as pigment in the building materials industry. Red oxide pigment containing about 70

% iron oxide was prepared from NALCO red mud by [8] after hot water leaching filtration, drying and sieving.
2.3.3 Red mud in the brick industry :
Dodoo- Arhin, et al [9] have been investigated bauxite red mud-Tetegbu clay composites for their applicability in the ceramic brick construction industry as a means of recycling the bauxite waste. The initial 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, mechanical strengths (modulus of rupture) increased with higher sintering temperature. The results obtained for various characterization analyses such as bulk densities of 1.59 g/cm3 and 1.51 g/cm3 compare very well with literature and hold potential in bauxite residue eco-friendly application for low-cost recyclable constructional materials. Considering the physical and mechanical properties of the fabricated brick samples, the batch formulation which contained 50% each of the red mud and Tetegbu clay is considered the best combination with optimal properties for the construction bricks application and it could be employed in lighter weight structural applications.
2.3.4. Red mud as filling material :
2.3.4.1 Road Base Material :
High-grade road base material using red mud from the sintering process is promising, that may lead to large-scale consumption of red mud. Based on the work of, a 15 m wide and 4 km long highway using red mud as a base material was constructed in Zibo, Shandong. A relevant department had tested the sub grade stability and the strength of road and concluded that the red mud base road meets the strength requirements of the highway.
2.3.4.2 Mining
Yang et al. [12], from the Institute of Changsha Mining Research, have studied the properties, preparation and pump pressure transmission process of red mud paste binder backfill material. Based on this study, a new technology named “pumped red mud paste cemented filling mining” has been developed by the Institute of Changsha Mining Research, in cooperation with the Shandong Aluminum Company. They mixed red mud, fly ash, lime and water in a ratio of 2:1:0.5:2.43, and then pumped the mixture into the mine to prevent ground subsidence during bauxite mining. The tested 28-day strength can reach to 3.24 MPa. This technology is a new way not only for the use of red mud, but also for non-cement cemented filling, successfully resolving the problem of mining methods in the Hutian bauxite stop. Underground exploitation practice on the bauxite has proved that cemented filling technology is reliable and can effectively reduce the filling costs, increase the safety factor of the stop and increase the comprehensive benefits of mining [13].
2.4. Recovery of components from red mud :
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, the content of TiO in red mud produced in India can be as much as 24%. Because of the huge amount of red mud, value elements like Ga, Sc, Nb, Li, V, Rb, Ti and Zr are valuable and abundant secondary resources. Therefore, it is of great significance to recover metals, especially rare earth elements, from red mud. Due to the characteristics of a high iron content, extensive research into the recovery of iron from Bayer process red mud have been carried out by scientists all over the world. The recycling process of iron from red mud can be divided into roasting magnetic recovery, the reducing smelting method, the direct magnetic separation method and the leaching extraction method, according to the different ways of iron separation. Researchers in Russia, Hungary, America and Japan have carried out iron production experiments from red mud. Researchers from the University of Central South have made steel directly with iron recovered from red mud [14]. The Chinese Metallurgical Research Institute has enhanced the iron recovery rate to 86% through making a sponge by red mud-magnetic separation technology. Sun et al. [15] researched magnetic separation of iron from Bayer red mud and

determined the process parameters of the magnetic roasting-magnetic selecting method to recover concentrated iron ore.

3. EXPERIMENTAL PROGRAMME

3.1 : Material study

The properties of material used for making concrete mix are determined in laboratory as per relevant codes of practice. Different materials used in present study were cement, coarse aggregates, fine aggregates and red mud. Aim of the study of various properties is to check the appearance with codal requirements and to enable an engineer to design a concrete mix for a particular strength.

3.2.1. TEST ON CEMENT

3.2.1.1. Consistency of Standard Cement Paste :

Apparatus: Vicat apparatus conforming to IS : 5513-1976, Balance, Gauging Trowel, Stop Watch, etc.
Procedure:

1. The standard consistency of a cement paste is defined as that consistency which will permit the Vicat plunger to penetrate to a point 5 to 7 mm from the bottom of the Vicat mould.
2. Initially a cement sample of about 400 g was taken in a tray and was mixed with a known percentage of water by weight of cement, starting from 26% and then it was increased by every 2% until the normal consistency was achieved.
3. Prepared a paste of 400 g of Cement with a weighed quantity of potable or distilled water, taking care that the time of gauging was not less than 3 minutes, nor more than 5 min, and the gauging completed before any sign of setting occurs. The gauging time was counted from the time of adding water to the dry cement until commencing to fill the mould.
4. Filled the Vicat mould (E) with this paste, the mould resting upon a non-porous plate. The mould was completely filled to the top of the mould. The mould was then slightly shaken to expel the air entrapped water.
5. Then we placed the test block in the mould, together with the non-porous resting plate, under the rod bearing the plunger; lowered the plunger gently to touch the surface of the test block, and quickly released, allowing it to sink into the paste. This operation was carried out immediately after filling the mould.
6. Then we prepared trial pastes with varying percentages of water and tested as described above until the amount of water necessary for making up the standard consistency as defined in Step 1 is found.

Observation:

Sr. No.	**Weight of cement (gms)**	**Percentage by water of dry Cement (%)**	**Amount of water added (ml)**	**Unpenetrated depth (mm)**
1	400	26	104	38
2	400	28	112	36
3	400	30	120	30
4	400	32	128	12
5	400	33	132	6

Conclusion / Result :

The normal consistency of a given sample of cement is 33 %. 3.2.1.2. Setting Time of Standard Cement Paste .

Apparatus: Vicat apparatus conforming to IS : 5513-1976, Balance, Gauging Trowel, Stop Watch, etc.
Procedure:

1. Preparation of Test Block – We Prepared a neat 400 gms cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency i.e 112 ml. Potable or distilled water was used in preparing the paste.
2. A stop-watch was started at the instant when water was added to the cement. The Vicay mould was filled with a cement paste gauged as above, the mould resting on a nonporous plate. Filled the mould completely and smoothened off the surface of the paste making it leveled with the top of the mould.
3. Immediately after moulding, placed the test block in the moist closet or moist room and allowed it to remained there except when determinations of time of setting were being made.
4. Determination of Initial Setting Time - Placed the test block confined in the mould and resting on the non-porous plate, under the rod bearing the needle (C); lowered the needle gently until it comes in contact with the surface of the test block and quickly released, allowing it to penetrate into the test block.
5. This procedure was repeated until the needle, when brought in contact with the test block and released as described above, fails to pierce the block beyond 5.0 ± 0.5 mm measured from the bottom of the mould shall be the initial setting time.
6. Determination of Final Setting Time - Replaced the needle (C) of the Vicat apparatus by the needle with an annular attachment (F).
7. The cement shall be considered as finally set when, upon applying the needle gently to the surface of the test block, the needle makes an impression there on, while the attachment fails to do so.
8. The period elapsing between the time when water is added to the cement and the time at which the needle makes an impression on the surface of test block while the attachment fails to do so shall be the final setting time.

Observation:
1. Weight of given sample of cement is _ _400 _ _ gms
2. The normal consistency of a given sample of cement is _ _33 _ %
3. Volume of water addend (0.85 times the water required to give a paste of standard consistency) for preparation of test block _ _112 _ _ ml

Conclusion / Result :
i) The initial setting time of the cement sample is found to be 95 minute..
ii) The final setting time of the cement sample is found to be 365 minute… 3.2.1.3. Specific gravity of cement

Apparatus : Specific gravity bottle 50 ml capacity, glass rod, kerosene, weighing balance. Procedure:
1. We took a specific gravity bottle and cleaned it properly and the weight of the empty bottle was taken and noted down.
2. Then cement about half of the bottle was taken and put it carefully in the bottle, the outer surface of the bottle was cleaned and the weight of the bottle was taken.
3. Kerosene was added to the bottle to the half of the bottle and stirred it with the glass rod to remove the air voids.
4. After mixing properly filled the rest of bottle with kerosene and weight was taken.
5. Then the material was taken out from the bottle and cleaned it completely and left it for some time.
6. The weight of the bottle filled completely with kerosene was taken and noted down.
7. The bottle then wash with water and filled with only water and weighed.

Observation table :

Sl.no	Weight of the empty bottle	Weight of bottle +cement	Weight of bottle +cement+ kerosene	Weight of jar + kerosene	Weight of jar + jar	Specific gravity
1	32.42	58.66	92.88	74.29	85.05	2.74
2	32.42	54	90.07	74.59	85.15	2.82

Calculation :
Specific gravity of kerosene = M4 – M1 / M5 – M1
=.799
Average specific gravity = 2.78 Conclusion :
The specific gravity of given cement sample is 2.78 .

3.2.2 TESTS ON FINE AGGREGATES
3.2.2.1. Particle Size Distribution of Fine Aggregates Theory :
The following limits may be taken as guidance: Fine sand : Fineness Modulus : 2.2 - 2.6, Medium sand : F.M. : 2.6 - 2.9, Coarse sand : F.M. : 2.9 - 3.2
Sand having a fineness modulus more than 3.2 will be unsuitable for making satisfactory concrete.
Apparatus:
Test Sieves conforming to IS : 460-1962 Specification of 4.75 mm, 2.36 mm, 1.18 mm, 600 micron, 300 micron, 150 micron, Balance, Gauging Trowel, Stop Watch, etc.
Procedure:
1. The sample was brought to an air-dried condition before weighing and sieving. The air- dried sample was weighed and sieved successively on the appropriate sieves starting with the largest.
2. The shaking was done with a varied motion, backward sand forwards, left to right, circular clockwise and anti-clockwise, and with frequent jarring, so that the material was kept moving over the sieve surface in frequently changing directions.
3. Light brushing with a fine camel hair brush was used on the 150-micron and 75-micron IS Sieves to prevent aggregation of powder and blinding of apertures.
4. On completion of sieving, the material retained on each sieve, was weighed and noted down.

IS Sieve (mm)	Weight Retained on Sieve (gms)	Cumulative of weight retained %	Cumulative Percentage of weight retained %	Cumulative Percentage of weight passing %
4.76	0	0	0	100
2.36	15	15	1.5	98.5
1.18	67	82	8.2	91.8
600	105	187	18.7	81.3
300	546	733	73.3	29.7
150	244	977	97.7	2.3
Pan	23	1000	100	0
Total	1000		299.4	

Calculation:
Fineness modulus is an empirical factor obtained by adding the cumulative percentages of aggregate retained on each of the standard sieves ranging from 4.75 mm to 150 micron and dividing this sum by an

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 10, No. 1, October : 2023

Finess Modulus =
= 299.7 / 100
=2.997
Conclusion :
i) Fineness modulus of a given sample of fine aggregate is 2.997 that indicate Coarse sand.
ii) The given sample of fine aggregate is belong to Grading Zones IV

Table 3.15. Grading limits of fine aggregates IS: 383-1970

I.S. Sieve Designation	Percentage passing by weight for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10 mm	100	100	100	100
4.75 mm	90–100	90–100	90–100	95–100
2.36 mm	60–95	75–100	85–100	95–100
1.18 mm	30–70	55–90	75–100	90–100
600 micron	15–34	35–59	60–79	80–100
300 micron	5–20	8–30	12–40	15–50
150 micron	0–10	0–10	0–10	0–15

3.2.2.2 Specific Gravity of Fine Aggregate :
Apparatus : Pycnometer of about 1 litre capacity, Weighing balance, with an accuracy of 1g. , Glass rod.

Procedure:
1. Clean and dried the Pycnometer. Tightly screwed its cap. Took its mass (M1) to the nearest of 0.1g.
2. Marked the cap and Pycnometer with a vertical line parallel to the axis of the Pycnometer to ensure that the cap is screwed to the same mark each time.
3. Unscrewed the cap and placed about 200g of oven dried sand in the Pycnometer. Screwed the cap. Determined the mass (M2).
4. Unscrewed the cap and added sufficient amount of de-aired water to the Pycnometer so as to covered the soil. Screwed on the cap.
5. Filled the Pycnometer with water completely upto the mark. Dried it from outside. Took its mass (M3)..
6. Filled the Pycnometer with water only. Screwed on the cap upto the mark. Wipe it dry. Took its mass (M4).

Sl. No.	Mass of empty Pycnometer (M_1)	Mass of Pycnometer and dry sand (M_2)	Mass of Pycnometer, sand and water (M_3)	Mass of Pycnometer and water (M_4)	Specific gravity
1	250	560	845	650	2.69
2	250	585	865	650	2.79
3	250	573	855	650	2.74

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 10, No. 1, October : 2023

Conclusion / Result :

i) The Specific Gravity of a given sample of fine aggregate is found to be …2.74….

ii) The Water Absorption of a given sample of fine aggregate is found to be …1.0…. % 3.2.3. Tests On Coarse Aggregate

3.2.3.1. Determination of Specific Gravity of Course Aggregate Apparatus: Measuring jar, weighing balance, aggregate, stopper. Procedure :

1. First thoroughly cleaned the specific gravity jar.
2. Then took the empty weight of the jar and noted down as M1 and filled it with aggregate of size 20 mm and down size.
3. Then the weight of the jar with aggregate was taken as M2.
4. Then water was poured into the jar and shaked properly so that no air voids will remains inside and it's weight was noted down as M3.
5. Removed all the materials and then the weight of the jar completely filled with water was taken as M4.
6. Then the specific gravity was found out.

Sl.no	Weight of the empty jar	Weight of jar + aggregate	Weight of jar + aggregate + water	Weight of jar + water	Specific gravity
1	242	1010	1708	1222	2.72
2	242	1055	1743	1219	2.70

Conclusion / Result :

i) The Specific Gravity of a given sample of coarse aggregate is found to be 2.71.

ii) The Water Absorption of a given sample of fine aggregate is found to be 0.5 %. 3.3 METHODS OF MIX DESIGN

Most of the available mix design methods are based on empirical relationships, charts and graphs developed from extensive experimental investigations. Basically they fallow the same principles enunciated in the preceding section and only minor variations exists in different mix design methods in the process of selecting the mix proportions. The requirements of the concrete mix are usually detected by the general experience with regard to the structural design conditions, durability and conditions of placing.

3.3.1 :- Factors affecting the choice of mix proportions

Compressive strength, workability, durability, Maximum nominal size of aggregate, Grading and type of aggregate, quality control

3.3.2 :- Mix proportions designations Stipulation for proportioning :

1. Grade designation : M25.
2. Type of cement : PPC 53 grade
3. Maximum nominal size of aggregate : 20 mm
4. Minimum cement content : 320 kg/m3
5. Maximum w/c ratio : .45
6. Workability : 100 mm (True slump)
7. Type of aggregate : Crushed angular
8. Maximum cement content : 450 kg/m3
9. Degree of workability desired : 100 mm (True slump)
10. Standard deviation (S) of compressive strength of concrete : 4

Test data for materials :According to IS: 456–2000 and IS: 1343–'80, the characteristic strength is defined as that value below which not more than 5 per cent results are expected to fall, in which case the Target mean strength for mix design

1. Cement used : PPC 53 grade
2. Specific gravity of cement : 2.78
3. Specific gravity of coarse aggregate : 2.71
4. Specific gravity of fine aggregate : 2.74
5. Water absorption of coarse aggregate : 0.5%
6. Water absorption of fine aggregate : 1.0%
7. Free moisture content : Nil
8. Zone of fine aggregate : Zone IV

Result/ Mix proportion :
Final Mix Proportion by IS code Method of Mix Design

Ingredients	Cement	Fine aggregate	Coarse aggregate	water
Quantity kg/m3	458.13	570	116508	197
Ratio	1	1.628	3.33	0.43

<u>Mix proportion for preparation of cubes</u>

Sl no.	Cement replaced (%)	Cement (kg)	Red mud (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (ml)
1	0	16.0	0	26.048	53.28	7300
2	5	15.2	0.8	26.048	53.28	7300
3	10	14.4	1.6	26.048	53.28	7300
4	15	13.6	2.4	26.048	53.28	7300
5	20	12.8	3.2	26.048	53.28	7300
6	25	12.0	4.0	26.048	53.28	7300

3.4. MAKING AND CURING CONCRETE CUBES

3.4.1 Weighing:

1. The quantities of cement, each size of aggregate, and water for each batch was determined by weight, to an accuracy of 0.1 percent of the total weight of the batch.

3.4.2 Hand Mixing:-

1. The cement and fine aggregates were mixed dry until the mixture was thoroughly blended and uniform in colour,
2. The coarse aggregate was then added and mixed with the cement and fine aggregate until the coarse aggregate was uniformly distributed throughout the batch.
3. The water then added and the entired batch mixed until the concrete appears to be homogeneous and has the desired consistency.
4. Repeated mixing was done, because of the addition of water in increments while adjusting the consistency, the batch then discarded and a fresh batch made without interrupting the mixing to make trial consistency tests.

3.4.3 Place of Moulding:

1. The specimens were moulded as near as practicable to the place where they were to be stored during the first 24 hours.
2. The moulds were placed on a rigid surface free from vibration and other disturbances

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 10, No. 1, October : 2023

3.4.4 Placing:

1. Placed the concrete in the moulds using a trowel.
2. Then moved the trowel around the top edge of the mould as the concrete was discharged in order to ensure symmetrical distribution of the concrete and for minimizing segregation of coarse aggregate within the mould.
3. Further distributed the concrete by use of a tamping rod prior to the start of consolidation.

3.4.5 Curing:-

1. The test specimens were stored in a place, free from vibration at a temperature of 27° ± 2°C for 24 hours from the time of addition of water to the dry ingredients.
2. After this period, the specimens were marked and removed from the moulds and, unless required for test within 24 hours, immediately submerged in clean, fresh water and kept there until taken out just prior to test.

4. RESULTS AND DISCUSSION

4.1. Observation and Result :

With the above said objectives and aim, a comparative study on strength parameters is done against conventional concrete to study the behavior of cement concrete with red mud. The experimental tests carried out on parameters are;

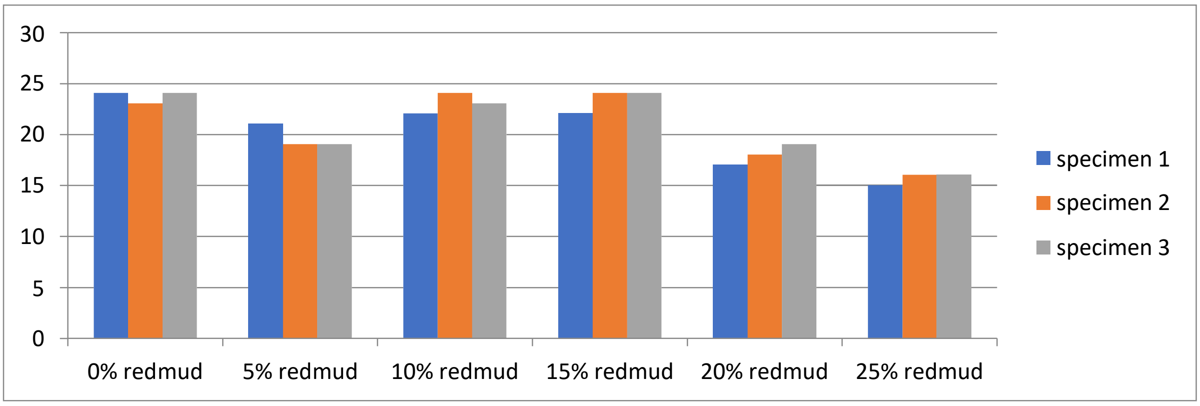
* The physical properties of blended cement replaced by 0%, 5%, 10%, 15%, 20% and 25% on weight basis by red mud.
* With constant water/cement ratio three concrete design mix of grade M25 was prepared and each concrete design mix was studied for Compressive strength.

Compressive strength of the concrete design mix was check by casting and testing of cubes (size 150 mm x 150 mm x 150 mm) after the curing period of 7 days, 14 days & 28 days.

The obtained results are tabulated below

Grade of Concrete			**% Replacement**			
	0%	**5%**	**10%**	**15%**	**20%**	**25%**
M25	24.075	21.065	22.069	22.069	17.053	15.047
M25	23.072	19.059	24.075	24.075	18.056	16.050
M25	24.075	19.059	23.072	24.075	19.059	16.050

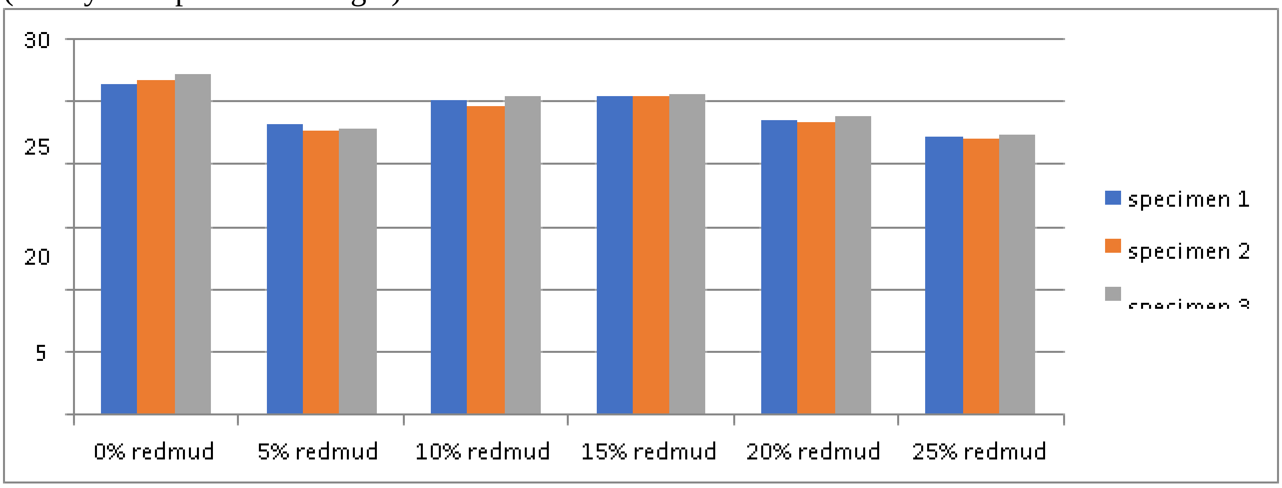
(7 days compressive strength)



(Graph showing 7 days compressive strength)

Grade of			**% Replacement**			
Concrete	**0%**	**5%**	**10%**	**15%**	**20%**	**25 %**
M25	26.44	23.11	25.11	25.33	23.55	22.22
M25	26.67	22.67	24.67	25.33	23.33	22.0
M25	27.11	22.89	25.33	25.56	23.78	22.44

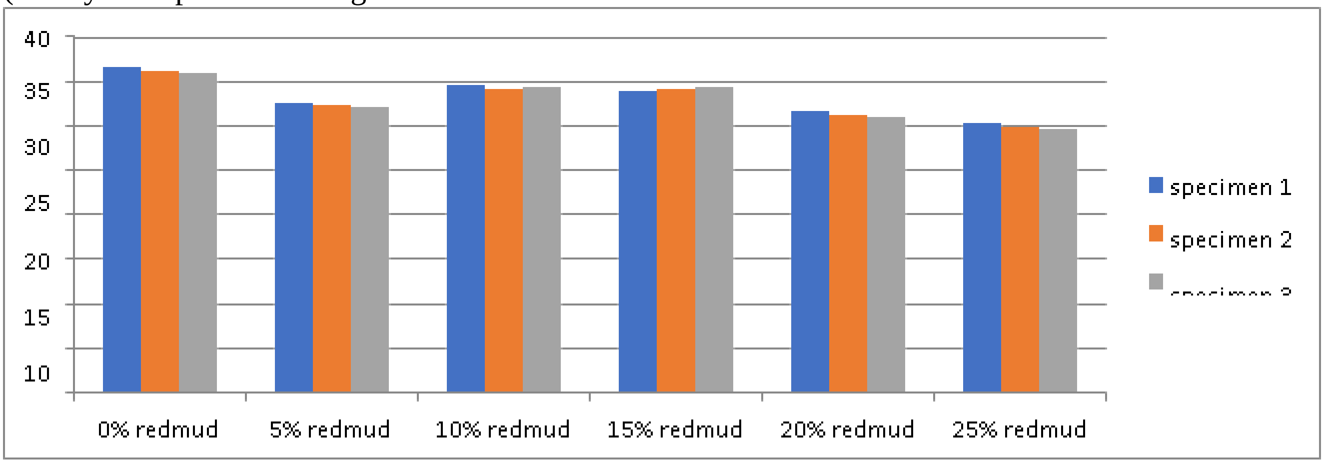
(14 days compressive strength)



(Graph showing 14 days compressive strength)

Grade of Concrete	% Replacement					
	0%	**5%**	**10%**	**15%**	**20%**	**25%**
M25	36.67	32.67	34.67	34.0	31.56	30.22
M25	36.22	32.22	34.22	34.22	31.11	29.78
M25	36.0	32.0	34.44	34.44	30.88	29.56

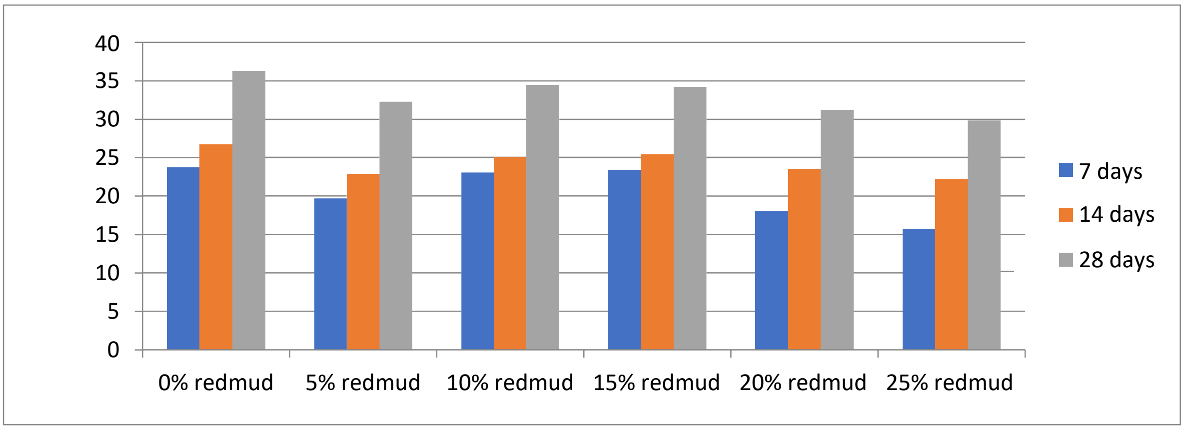
(28 days compressive strength



(Graph showing 28 days compressive strength)

Grade of Concrete	% Replacement					
	0%	**5%**	**10%**	**15%**	**20%**	**25%**
	23.741	19.727	23.072	23.406	18.056	15.715
M25						
M25	26.74	22.89	25.036	25.406	23.553	22.22
M25	36.297	32.297	34.443	34.22	31.183	29.853

(7,14,28 days average compressive strength)



(Graph showing 7,14,28 days average compressive strength) 5. GENERAL OBSERVATION AND CONCLUSION

5.1 General Observation

- For M 25 grade of concrete design mix there was an initial decrease in the compressive strength for 5 % replacement of cement by RM.
- But from the next replacements i.e. 10 % and 15 % the compressive strength are increased with the increase in the % replacement of cement by RM. Then after, for 20 % and 25 % replacement of cement by RM there was a decrease in the compressive strength as the % replacement of cement by RM increased.
- Hence by observing all graphs of each grade of concrete design mix, it can be said that the 15 % replacement of cement by RM gives the maximum compressive strength.

5.2.CONCLUSION

- From this experimental study following points can be drawn: After testing of 5 blended cement samples (5% to 25 % replacement of Cement by RM) with an increment of 5 %, it can be said that the optimum use of RM is 15% as a partial replacement of cement by RM.
- The percentage economy is increased with the increase in the grade of concrete but at the same time there is a reduction in the percentage increase in the Compressive Strength.
- Considering all the above point it is interesting to say that the optimum utilization of Red Mud in concrete is 15 % as a partial replacement of cement by RM.

5.3 Future Scope

1. In the present study 25% replacement of cement has been considered. The other percentages i.e 30,40,50 percentage need investigation
2. Red mud has been used fro experimental work obtained from Bayer process in Aluminium industry. This red mud need investigation after neutralization
3. Red mud obtained from other industries need investigation on the strength characteristics of concrete
4. Strength properties of concrete with partial replacement of cement with red mud need investigation for longer period i.e 60,90.180.360 days

References:-

1. Chandra, S., 1996. Waste materials used in concrete manufacturing. Elsevier.
2. IS 10262- 2007 Recommended Guidelines for Concrete Mix Design
3. IS 456- 2000 Plain and Reinforced Concrete - Code of Practice
4. IS 516- 1959 Methods of Tests for Strength of Concrete
5. IS 5816-1999 Splitting Tensile Strength of Concrete -Method of Test

6. M. L. Gambhir, Concrete Technology (3rd Edition), Published by The McGraw-Hill Companies, New Delhi .
7. M. S. Shetty, Concrete Technology Theory & Practice, Published by S CHAND & Company, Ram Nagar, New Delhi .
8. D.K. Grubbs, S.C. Libby, J.K. Rodenburg, K.A. Wefers, The geology mineralogy and clarification properties of red and yellow Jamaican bauxites, in Proceedings of the Bauxite Symposium IV, J. Geol. Soc. Jamaica (1980) 176-186.
9. Dr. D S V Prasad, Dr. G V R Prasad Raju & M Anjan Kumar, Utilization of Indusrtial waste in Flexible Pavement Construction, downloaded from www.ejge.com.
10. .Dr. K. K. Jain, S. K. Singh and Laljee Sahu, „The Geo Technical properties of Red Mud and Red Mud Lime Mixtures 0, Indian Highways, October 2001. ph. 120-127.
11. Dr. R. P. Joshi, V.G.M. Desai and B. S. Shetty, „The use of locally available materials for low cost housingD, Proceeding of National n „Recent advances in low cost building material and seminar o technology J, Anantapur 1992. ph. 214-227 .
12. Dr. Y. P. Kalcar, „Management of Industrial Solid Waste Need for ineering & Construction Review, February 1998. RecyclingD, Civil Eng Ph 67-71
13. Qi, J.Z., Yang, J., Wang, M. and Xiao, B., 2005. Experimental research on road materials of red mud. University of Huazhong Science and Technology: Wuhan, China, 82.
14. Sun, Y.F., Dong, F.Z., Liu, J.T. and WANG, S.H., 2009. Technology for recovering iron from red mud by Bayer process. Met. Mine, 9, pp.176-178.