TESTING AND MIX DESIGN PROCEDURE OF PARTIAL REPLACEMENT OF CEMENT BY RED MUD UNDER CURING OF IN ORGANIC SUBSTANCES (HCL, NaOH & NaCL)

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ABSTRACT

The several different materials were used in the field of civil engineering. At present there are many construction materials available in the construction field. This huge amount of industrial by-products or wastes is generating a huge amount of resources which are unutilized. This research is aimed at finding out usage of such industrial by-products such as Red Mud. Red mud waste material generated by the Bayer Process widely used to produce alumina Bauxite throughout the world. The study included reinforced concrete beams by the partial replacement of OPC with red mud and to notice the effects of acid, base and salt conditions was discussed in this paper. This paper describes the effect addition of red mud in concrete. Because of storing issue, the waste negatively affects the environment. In this research work red mud is replaced the OPC at different proportions such as 5 %, 10%, 15% and 20 %.a and also we have analyzed the physical and chemical properties of red mud in order to find the strength parameters such as compressive strength, flexural strength of reinforced concrete beam and durability aspects. Beams were cured in three types of solutions which was involved HCL (acid), NAOH (base) &NACL (salt). The effect of adding different percentages of red mud as additional material to concrete mixes on their compressive strength, resistance to sulfates, acid, base and salt were studied. The results were obtained and compared with controlled M25 grade concrete. Red mud blended mixes shown poor results against HCl attack and observed greater resistance against NaCl and NaOH attack.

Keyword *Cement mortar, hydrated lime, monotonic load and Deflection.*

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1. Introduction

India contributes just around 3% of world's generation out of aggregate Aluminum creation. Red mud is one of the amid refining procedure of Bauxite mineral of Aluminum Al2O3, bi-item at present its developed rate is more than 120 million tons is evaluated to be 2.7 billion tons. High pH more prominent than 1.1 Because of nearness of scathing pop the Red Mud. It is unsafe to condition and its transfer is tricky. Keeping in mind the end goal to beat this issue it must be reused in different fields like structural designing, horticultural and gas medications, for example, Embankments, Bricks planning, Landfill liners, and for road asphalts. Utilized the Red mud for blocks planning and checked the dry and wet compressive qualities at 28 days curing period by balancing out with lime, got most extreme qualities for 5% to 8% lime separately. They have done a venture deal with practicality of lime and Red mud settled down Red mud blends in street development arranged bond. Meeting the prerequisite of bond cement utilized for asphalt materials at 28-day compressive quality is around 30–40 MPa because the compressive and flexural quality of this sort of cement is near or much higher than that of customary solid. The 28-day flexural quality is around 4.5 to 5.5MPa. examined slag and Red mud initiated by a composite strong soluble activator, and created antacid slag Red mud bond which has the properties of high compressive quality (the 28-day compressive quality can be up to 125 MPa), brilliant imperviousness to erosion, using 30% of the Red mud and more prominent early quality (the underlying and last setting is independently 62 min and 95 min). Reported that the use of phosphor gypsum, impact heater slag, Red mud, fly ash, squander tea, and so on are utilized as development materials and the long time ecological effect of such techniques have been considered. Utilized the impacts of Red mud on the unconfined compressive quality Red mud as a concrete stabilizer, swelling rate of compacted earth liners as water powered obstruction and study pressure driven conductivity. The test outcomes demonstrate that compacted mud tests containing cement-Red mud and Red mud added substances have diminished water driven conductivity and high compressive quality and swelling rate when contrasted with normal earth tests. Thusly, it is presumed that cement-Red mud and Red mud materials can be effectively utilized for the adjustment of dirt liners in geotechnical applications. The 28-day 2 compressive quality of the bond quality can achieve 63MPa and has concentrated the planning of conventional Portland concrete from Red mud, free stone and lime.

Deville Process

The first industrial process used to produce alumina from bauxite is Deville process. In 1859 Frenchman Henri Sainte-Claire Deville invented the process. It is also called the Deville-Pechiney process. It is based on the extraction of alumina with carbonate the first stage is the calcination of the bauxite at 1200 °C with coke and sodium carbonate. The alumina is converted in sodium aluminate and Iron oxide remains unchanged and silica forms a polysilicate. In the second stage sodium aliminate is dissolved by adding sodium hydroxide solution, leaving the impurities as a solid residue. the amount of silica present in the raw material based on that the amount of sodium hydroxide solution needed. Carbon is bubbled through the solution when the solution is filtered off. The latter can be recovered and reused in the first stage. Leaving a solution of sodium carbonate, causing aluminium hydroxide to precipitate. Alumina is produced by the calcined aluminum hydroxide. Until the outbreak of the Second World War this process was used in France at Salindres until 1923 and in Germany and Great Britain. Now Deville process replaced by the Bayer process. 3

Bayer Process

The Bayer process is the principal industrial means alumina (aluminium oxide) is refining by bauxite. The most important ore of aluminium is bauxite, contains only 30–60% aluminium oxide, (alumina), Al_2O_3, the rest being a mixture of titanium dioxide, silica and various iron oxides. Aluminium metal can be refined before it can be purified as aluminium oxide. Bauxite ore is mixture of hydrated aluminium oxides and iron (i.e., compounds of other elements). In the Bayer process, bauxite ore is heated at a temperature of 150 to 200 °Cin a pressure vessel along with a sodium hydroxide solution. In an extraction process the aluminium is dissolved as sodium aluminate the temperatures 150 to 200 °C.The aluminium compounds in the bauxite is present as diaspore(AlOOH), gibbsite($Al(OH)_3$) &boehmite(AlOOH).Extraction conditions will be dictate by different forms of the aluminium component. After separation of the residue by filtering, when the liquid is cooled then gibbsite (aluminium hydroxide) is precipitated and then fine-grained aluminium hydroxide is seeded. The extraction process in the ore to soluble sodium aluminate, $2NaAlO_2$is converts byaluminium oxide, according to the chemical equation shown below.

$$Al_2O_3 + 2\ NaOH \rightarrow 2\ NaAlO_2 + H_2O$$

The other components of bauxite do not dissolve but this treatment also dissolves silica. At the stage of precipitation the silica converts to calcium silicate, sometimes lime is added. To remove the fine particles the solution is clarified by filtering off the solid impurities, with the aid of a flocculant such as starch and commonly with a rotary sand trap. bauxite tailings, contains calcia, titania, iron oxides, silica, and some unreacted alumina The undissolved waste after the aluminium compounds are extracted,. A method by which aluminium hydroxide precipitates and treated by bubbling carbon dioxide through it after the original process was that the alkaline solution was cooled.

$$2\ NaAlO_2 + CO_2 \rightarrow 2\ Al(OH)_3 + Na_2CO_3 + H_2O$$

But later, this gave way to form high-purity aluminium hydroxide ($Al(OH)_3$) crystal by seeding the supersaturated solution, which more economically feasible and was eliminated the need for cooling the liquid.

$$2\ H_2O + NaAlO_2 \rightarrow Al(OH)_3 + NaOH$$

The production of the aluminium hydroxide sometimes used aluminium sulfate in the manufacture of water treatment chemicals, sodium aluminate or PAC (Poly aluminium chloride).A significant amount is also used as aplastics as a fire retardant and filler in rubber. Some 90% of the gibbsite production is converted into aluminium oxide, (Al_2O_3), at a temperature in excess of 1000 °Cby heating in fluid flash calcinersor rotary kilns.

$$2\ Al(OH)_3 \rightarrow Al_2O_3 + 3\ H_2O$$

The recycling of left-over or 'spent' sodium aluminate solution is done. So these can be extracted This, however, allows vanadium impurities and gallium to build up in the liquors. The Bayer process becomes uneconomic for the bauxites having more than 10% silica, due to insoluble sodium aluminium silicate which reduces to yield being formed, or another process must be chosen. By usingHall–Héroult process to produce aluminium over 90% of the aluminium oxide is produced.

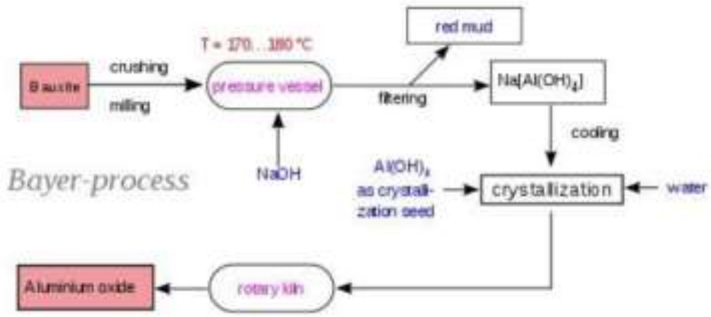

Fig-1: The flow chart represents the Bayer process.

Red Mud

Red mud is a highly alkaline waste product that is generated in the industrial production of alumina (aluminium oxide) composed mainly of iron oxide,widely used in the manufacture of refractories, ceramics and abrasives and also this raw material used in the manufacture of aluminium metal. Annually, causing serious disposal problem in the mining industry, about 77 million tons of the red mud wastes are produced every year. Issues with its storage are reviewed the important one scale of production makes the waste product, and to use for it every opportunity is explored to find. Through the process over 95% of the alumina produced globally, approximately 1 to 1.5 tons of bauxite tailings/residue is produced for every ton of alumina produced. Resulting in the generation of about 150 million tones of bauxite tailings/residue for annual production of alumina in 2015 was approximately 115 million tones.

2. Literature Review

VenkateswaraRao.J, RamaraoChimata [2014]: have made investigation for studying mechanical properties of rigid pavements on glass fibers and quarry dust as a partial replacement of sand for studying mechanical properties of rigid pavements. The percentage of glass fiber as a partial replacement of sand in concrete is 0.2 is constant for all experimental studies and 0%, 10%, 15%, 20%, 30% and 40% quarry dust for M40grade concrete. From experimental studies 30% of quarry dust & 0.2% glass fibers as a partial replacement of sand are improved hardened concrete properties.

Ashok. P, Suresh Kumar. M.P [2015]: experimental studies on partial replacement of cement M30 grade by utilizing red mud and hydrated lime as current byproducts. The percentage of hydrated lime as a partial replacement of cement in concrete is 5% is constant for all experimental studies and 0%, 10%, 15% and 20% red mud for M30grade concrete. From the experimental studies 15% of red mud & 5% hydrated lime as a partial replacement of cement is improved the concrete properties.

Suraj Khanate et al. [2015]: studied the Performance by using Non-conventional Reinforcement on Beam-Column Joint under Cyclic load techniques. The beam size is 150mm x 100mm x1000mm and column size is 200mm x 100mm x 1000mm. A refined model represents steel and concrete by different elements in FE model by using exterior beam column joint. As per IS13920:1993(conventional) guide lines details given to first specimen and additional diagonal cross bracing bars detailed to second specimen at joints and beam reinforcement (Non-conventional) of 10mm diameter. The author concluded that seismic performance is improved by cumulative energy dissipation, ductility factor, stiffness of non-conventional reinforcement.

3 Mix Design for M25 Grade

Design stipulations for concrete mix:
Characteristics of compressive strength at
(fck) = 40 N/mm2 at 28 days
Maximum size of aggregate = 20 mm
Degree of quantity of aggregate = Good (moderate in some cases)
Maximum cement content in concrete = 480 kg/m3
Minimum cement content in concrete = 300 kg/m3
Maximum water cement ratio for mix design = 0.4
Proposed water cement ratio for mix design = 0.4
Slump = 55 - 120
Degree of workability of concrete = 0.90 compaction factor (assumed)

Test data for materials in concrete:
Type of cement in mix design = OPC
Grade of cement in mix design = 53 grade
Specific gravity of cement = 3.16
Replacing material to cement = Red mud sludge
Dosage of red mud = 0%
Specific gravity of red mud as replacing material = 2.86
Coarse Aggregate in aggregates = 20 mm
Fine Aggregate in aggregates = Zone II

Target strength:
As per IS: 10262-2009 Table 1 "s" value is taken, Standard deviation from M25grade then good degree of control(s) =4 N/mm2 is taken as greater of two valves
Target strength of concrete = fck+ 1.65 × s'
= 25 + 1.65 × 4
= 31.6MPa

Selection of water-cement ratio in mix design:
Water-cement ratio is adopted in this investigation, hence for moderate exposure from durability point views max water-cement ratio is 0.5.
As per IS: 456-2000 water cement ratio is taken
Water cement ratio = 0.4

Water content:
As per IS: 10262-2009 in Table 2
Selection of water content in mix design = 186.0 + (6/100) × 186.0
= 197.27 kg/m3

Cement content:
Cement content in concrete = 197.16/0.4
= 492.0 kg/m3
Red mud sludge is replaced by 0% to the cement in concrete
Red mud content in concrete = 492.0 × (0/100)
= 0.0 kg/m3
Therefore the cement content in concrete = 492.0 – 0.0
= 492.0 kg/m3

Aggregate calculation:
Corrected coarse aggregate value in aggregate = 0.02+0.62
= 0.64 kg/m3
Therefore 0.62 from the table in IS: 456-2009 for 20mm in Zone2
The coarse aggregate is to be pumped then it reduced by 10% as wastage

The coarse aggregate in aggregates = 0.64 × (90/100)
= 0.575 m3/sec
The fine aggregate value in aggregates = 1 - 0.575
= 0.425 m3/sec

Volumes:
Volume of concrete for mix design = 1 m3
Volumes of cement content in concrete = {(mass of cement) / (Sp. g of cement)} × (1/1000)
= {(492.0)/ (3.15)} × (1/1000)
= 0.156 m3
Volume of water content for mix design = 197.16 lit
= 0.197 m3
Volume of red mud to be replaced = {(Mass of rm) / (Sp.g of rm)} × (1/1000)
= {(0.0)/ (2.86)} × (1/1000)
= 0.0 m3
Volume of total aggregate in concrete = 1 - {Vol. of cement + vol. of water + vol. of red mud}
= 1 - {0.156 + 0.197 + 0}
= 0.647 m3
Weight of coarse aggregate in concrete = Volume × C.A content × Sp. g of C.A × 1000
= 0.647 × 0.576 × 2.8 × 1000
= 1043.59 kg/m3
Weight of fine aggregate in concrete = Volume × F.A content × Sp. g of F.A × 1000
= 0.647 × 0.424 × 2.7 × 1000
= 740.79 kg/m3

Volumes:
Cement = 492.0 kg/m3
Water = 197.27 kg/m3
Fine aggregate = 740.79 kg/m3
Coarse aggregate = 1043.59 kg/m3
Red mud = 0.0 kg/m3
Total concrete weight = 2474.33 kg/m3

Ratio of mix design:

Cement	Fine aggregate	Coarse aggregate
492.0	740.79	1043.59
1	1.69	2.22

Design of Chemical Mix For Curing Purpose:
For NAOH:-**ph=12.0**
40.0 gm – 10.01ml – 1.0N
4.0 gm – 100.0ml – 0.10N
0.40 gm – 1000ml – 0.01N
That is 1.0 lt = 0.40 gm of NAOH
Total volume = 183.0 lts
183.0*0.40 = 74.0 gms
For HCL :-ph=2.0
from the text book 1.0 lt of HCL contains 1.0 molarities
that means (88.0ml – 1.0lt – 1.0M)
88.0ml of HCL – 1.0lt – 1.0 normality
0.880 ml of HCL – 1.0lt – 0.01N
Total required HCL (183.0*0.880 = 164.0 ml)
For ph= 4
For increasing the ph value the formula is (V1N1=V2N2)

That means (V1*10^-2 = 184.0*10.0^-4)
1.84.0 lts require for 184.0 lts of water

Cubes for Compressive Strength:
Remove projecting fins when the specimens took from curing tank and, if kept in atmosphere up to surface is dried from water. Noted the weight of specimen and dimension of the specimen to the nearest 0.2mm. Placed the cubical specimens in such a manner that the load was applied to opposite sides of the cubes as a cast (i.e. not to the top to bottom)after Cleaned the bearing surfaces of the testing machine the cylinder should be placed in a vertical direction no packing should be used between the steel plate and first specimen of the testing machine Apply load and continuously increase at the rate of approximately without any shock at 140 kn / sec until no greater load is sustained by the specimen. Calculate the cube strength noted the maximum load was applied to the specimen.

Fig-2: During Chemical curing of beams

Fig-3: compressive strength after loading

Beams for Compressive Strength:
Take the beams from curing tank and then remove projecting fins and kept in atmosphere up to beam dries from water on the surface. Noted the weight and dimension of the specimen to the nearest 0.2mm. Clean the bearing surfaces of the testing machine and then Place the specimens in such a manner the beam should be placed in a vertical direction that the load is applied to opposite sides of the beams as a cast (i.e. not to the top to bottom) no packing should be used between the steel plate and test specimen of the testing machine. The deflection of the beam at maximum load is drawn by attaching the LVDT stand below the surface the specimen. Applied load continuously increases at the rate of approximately at 1 kn / sec until no greater load was sustained by the specimen without any shock. Calculated the cube strength by the maximum load was applied to the specimen is noted.

Fig-4 During normal curing period

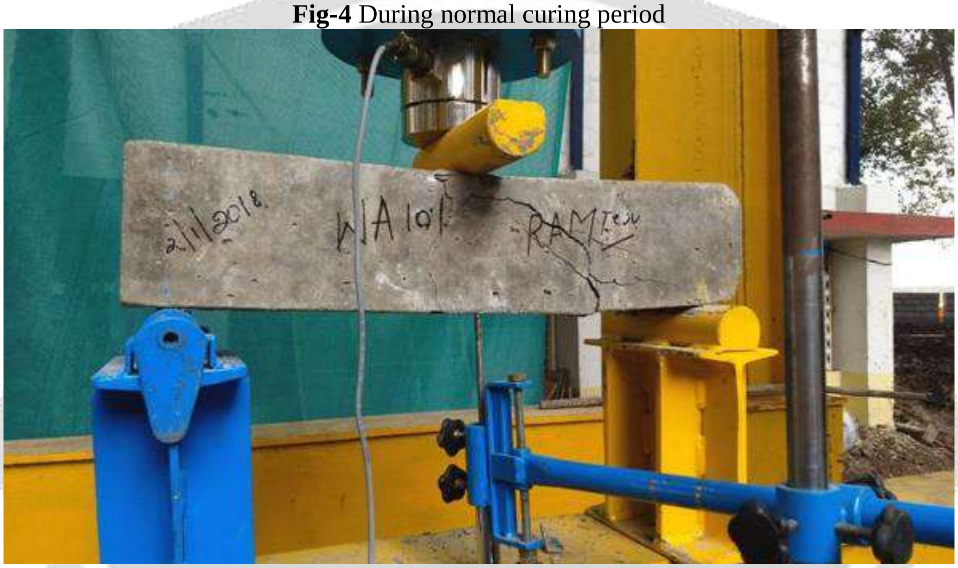

Fig-5: Test setup

Fig-6: Testing of beams

Results

Table 1 Compressive Strength of red mud Blended Cubes

S. No.	% of replacement	Compressive strength after 28 days of curing (MPa)
1	0	31.3
2	5	32.9
3	10	31.2
4	15	29.5
5	20	27.4

first 15 specimens were tested after 28 days of curing as one set and another 3 sets of specimens cured with acid, base and salt respectively for 90 days. Test setup of the specimen shown in figure 4, 50kN loading frame is used for testing of specimens at rate of loading 1kN/sec. Ultimate loads are shown in table 4 by testing of 3 sets of specimens were tested up to failure after 90 days of curing. By removal of moisture content from 2nd, 3rd and 4th set of specimen's weights were shown in table 5 before and after curing.

Table 2 Properties of Steel Reinforcement

S.No	Diameter of Specimen (mm)	Area of Specimen (mm^2)	Weight of Specimen (kg)	Ultimate Tensile Strength (mpa)	% of Elongation (mm)
1	10	78.73	0.618	636.83	23
2	10	78.47	0.618	625.91	20
3	10	78.47	0.616	624.89	24.5
4	12	113.1	0.888	588.17	21.17

Table 3 Ultimate load and deflection at ultimate load of R.C.C. specimens

S. No	Specimen	Ultimate load (kN)	Flexural Strength (MPa)	Deflection at ultimate load (mm)
1	C0RM	107.1	23.1	7.89
2	C5RM	97.9	21.18	7.22
3	C10RM	95.4	20.91	6.99
4	C15RM	85.9	18.69	6.37
5	C20RM	78.2	17.36	5.72
6	A0RM	109.9	22.68	9.69
7	A5RM	108.1	22.11	8.09
8	A10RM	100.3	20.11	6.3
9	A15RM	87.5	17.68	5.44
10	A20RM	82.1	17.34	8.61
11	B0RM	104.7	21.16	10.72
12	B5RM	110.1	23.16	8.47

Table 4 Weights of specimens before curing and after curing

Sl No	% of replacement	Acid Series (Kg s)		Base Series (Kg s)		Salt Series(Kg s)	
		Before Curing	After curing	Before Curing	After curing	Before Curing	After curing
1	0	42.58	41.8	42.74	41.68	42.75	42.18
2	5	42.88	41.93	42.54	42.07	42.74	42.66
3	10	42.73	42.51	42.67	42.41	42.44	42.61
4	15	42.91	42.58	42.54	42.14	42.78	42.44
5	20	42.55	42.18	41.87	41.67	42.95	42.53

Little deterioration is observed in all specimens by the weight difference between all mixes. The ultimate load of control specimen is 107.1 KN after 28 days of curing is higher among first set of specimens. Compressive strength of red mud is low so lower flexural strength is given by specimens after 28 days of curing. C5RM and C20RM have shown 8.35% and 26.23% lower than control mix respectively. First set of specimens shows load-deflection curves in figure 5 and it shows deflection is proportional to ultimate load.

4. CONCLUSIONS

The partial blending of red mud in some aspects the durability of the R. C. C beam is improved. All blended mixes are lower than spelling of material from control specimen. Red mud blended concrete mix shows greater resistance against NaCl and NaOH attack and it shows lesser resistance against HCl attack. 5% replacement of red mud in cement gives greater performance in resistance. B5Rm and S5RM shown 17.01% higher than normal concrete mix, B5RM shown 4.51% higher and A5RM shown 2.59% lower than control specimen mix. At 5% utilization of red mud S5RM is recommended to get optimum results in R.C.C beam. This type of concrete is suggestible for the construction of R.C.C buildings to avoid failures in coastal areas from high salty conditions.

5. REFERENCES

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