INTERNATIONAL JOURNAL
FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Properties of Red Mud Admixed Concrete

Er.Vedpal Nain[1], Er.Mohd. Usman[2], Er. Ayay Kumar[3], Er. Sanjay Sangwan[4]

[1,2,3]*Civil dept. Shree Siddhivinayak Group of Institutions kurukshetra university,*
[4]*Department of civil Engineering, H.C.T.M. Technical campus, Kurukshetra University,*

Abstract— Red mud is a by-product which is obtained during the Bayer's process of aluminium production. It is basically a waste material which is highly alkaline in nature and hence cannot be disposed off easily. If it is disposed in agricultural lands then that land becomes infertile for many years. Thus to protect our environment from the ill effect of red mud it is necessary to turn this waste into wealth. Red mud is composed of a mixture of solid and metallic oxide bearing impurities and presents one of the aluminium industries most important disposal problems. The red colour is caused due to the oxidized iron present which can make up to 60% of the mass of red mud. In addition to iron the other dominant particles includes silica, unbleached residual aluminium and titanium oxide. Red mud is a good binder material and can be used in concrete technology for construction practices with partial replacement with cement. The use of red mud with partial replacement of cement proves to be economical because red mud on being a by-product of alumina industry free of cost. Red mud increases the mechanical properties of concrete and as a result of which it is a good cementations material.

In this project we have done a comparative study on the fly ash and red mud as cementations admixtures and have discussed about the properties of red mud, its chemical composition and how it enhances the mechanical properties of concrete i.e., increases the compressive strength, flexural strength and tensile strength of concrete based on several research papers. We have also discussed about the properties of bricks that are manufactured out of red mud and how it is economical and how the use of it conserves the environment.

Keywords- Red mud, binder material, cementations material, compressive strength, flexural strength, tensile strength and cost analysis of red mud admixed concrete.

I.   INTRODUCTION

Red mud is a solid waste product of the Bayer process, the principal industrial means of refining bauxite in order to provide alumina as raw material for the electrolysis of aluminum by the Hall-Heroult process. Red mud is composed of a mixture of solid and metallic oxide-bearing impurities, and presents one of the aluminum industry's most important disposal problems. The red colour is caused by the oxidized iron present, which can make up to 60% of the mass of the red mud. In addition to iron, the other dominant particles include silica, unbleached residual aluminum, and titanium oxide.

II. LITERATURE REVIEW

A. An Overview of Chemical Processes To Manufacture Red Mud Construction Products By Arum S. Wagh, PhD

Major deposits of red mud are in highly populated emerging economic regions. Recycling red mud as construction materials is important to these countries for economic as well as environmental reasons. Room-temperature-setting chemical reactions to solidify red mud into construction products may be one way to recycle red mud. We present two methods developed by us, one in Jamaica and the other in U.S.A. The first method (Geopolymeric method) takes advantage of the high alkalinity and high alumina content in red mud. Adding sodium silicate, we developed sodium alumina-silicate binding phases in red mud. Using this process, Jamaica Bauxite Institute constructed a demonstration sports pavilion with red mud bricks. The second process is a by-product of "Ferro-Ceramicrete" developed in Argonne National Laboratory for immobilization of nuclear weapons legacy waste. In this process, we took advantage of high content of iron oxide (hematite) in red mud, and partially reduced a small portion of it to initiate activation reaction with an acid-phosphate. This process produces rapid-setting alternative red mud cement that can be used to manufacture concrete, bricks, and building blocks. Both processes have been proven and used in other fields.

B. Strengths of Red Mud

It is evident from the literature survey that red mud increases the strengths of concrete to a considerable extent.
It reduces the capillary pores of concrete and hence reduces permeability.
Red mud's pH value varies from 10 to 12 and as a result of which it prevents corrosion of reinforcement.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Use of red mud proves to be economical as it comes free of cost.

Red mud also serves as a decorative material.

It prevents early fading of colour.

It serves as a good binder material.

C. Weaknesses of Red Mud

Due to its high alkalinity it damages agricultural lands,

For disposing it should be washed seven times.

There are chances of leakages from red mud lake.

It contaminates the ground water table in case it is disposed underground.

III. METHODOLOGIES

Materials Used

Cement

Sand

Aggregate

Red Mud

Water

A. Cement P.P.C (53Mpa)

Portland pozzolona cement (ppc) is manufactured by the intergrading of OPC clinker with 10 to 25 % of pozzolanic material. A pozzolanic material is essentially a siliceous or aluminous material which while in itself possessing no cementations properties, which will, in finely divided form and in the presence of water, react with calcium hydroxide, liberated in the hydration process, at ordinary temperature, to form compounds possessing cementations properties.

B. Fine Aggregates (IS 383 & IS 516)

It should be passed through I. S. Sieve 4.75 MM. It should have the finest modulus 2.50 to 3.50 and silt contents should not be more than 4%. Coarse sand should be either river sand or pit sand; or combination of the two.

C. Water

Water used for all construction works like masonry work, making concrete, mortar, bricks, or for other plain or reinforced general construction, should be clean and free from objectionable quantities of suspended materials, vegetables, or organic impurities like alkalis, salts, and other deleterious substances.

D. Red Mud

Refs.	India (%)	Jamaica (%)	Brazil (%)	Australia (%)	US (%)
Fe_2O_3	26.40	53.8	43.7	32.82	46.25
Al_2O_3	26.24	10.33	16.76	25.29	14.80
TiO_2	22.10	8.58	4.00	8.68	5.86
Na_2O	4.20	8.25	9.80	16.77	1.85
SiO_2	6.55	8.25	9.80	1.677	4.17
CaO	3.50	n.g.	n.g.	2.11	8.8
CO_2	0.00	n.g.	n.g.	n.g.	n.g.
LOI	10.88	n.g.	n.g.	7.66	n.g.

Table 1 Chemical composition of red mud in different countries

E. Method`s Calculation (10262:2009)

Volume of one cube   =   3375 cm^3 (15cm*15cm*15cm)

	=	$3.375 \times 10^{-3}\,\text{m}^3$		
Density Of Concrete	=	24 MPa		
	=	$(3.375 \times 10^{-3}) \times 24$		
	=	0.081 KN		
	=	81 N		
Weight Of Cube	=	81/9.81	=	8.256 Kg
Ratio Used	=	1:1.5:3 (M20)		
Cement Required	=	1.50 Kg		
Sand Required	=	2.25 Kg		
Aggregate Required	=	4.5 Kg		
Total	=	8.25 Kg		

F. Materials Used

Red mud's of Chhattisgarh are localized in occurrence and are found mostly in the BALCO. These soils occur in catenary sequence along with late rites and are found mainly as deposits by colluviation in foothills and small hillocks.

The rapid permeability of the surface mud also has been responsible for the characteristic development of these red mud's, which are very deep and homogeneous without much expression of horizons. The mud's have red colour, which has been attributed to the presence of Fe_2O_3 or Al_2O_3, SiO_2 etc.

Mix composition (mud + ash)	Grain size analysis			Proctor density		Specific gravity
	Sand %	Silt %	Clay %	OMC %	Dry density (gm/cc)	
50%+50%	65	28	7	28	1.49	2.74
70%+30%	50	40	10	28	1.56	2.91
30%+70%	70	28	2	29	1.41	2.44
60%+40%	58	35	7	27	1.54	2.64
40%+60%	63	32	5	28	1.52	2.68

Table 2 - Particle size, compaction parameters & specific gravity of mix composition

G. Test for Compressive Strength

Sr. No.	Max. load At failure (N)	Size of bricks	Area of bricks (sq.mm)	Compressive strength (N/sq.mm)	Average compressive strength (N/sq.mm)
1	90000	190×90×90	17100	5.26	
2	95000	190×90×90	17100	5.56	
3	85000	190×90×90	17100	4.97	5.15
4	90000	190×90×90	17100	5.26	
5	80000	190×90×90	17100	4.68	
6	90000	190×90×90	17100	5.26	
7	100000	190×90×90	17100	5.85	
8	85000	190×90×90	17100	4.97	5.03
9	85000	190×90×90	17100	4.97	
10	70000	190×90×90	17100	4.09	
11	80000	190×90×90	17100	4.68	
12	90000	190×90×90	17100	5.26	
13	100000	190×90×90	17100	5.85	5.26
14	85000	190×90×90	17100	4.97	

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

15	95000	190×90×90	17100	5.56	
16	95000	190×90×90	17100	5.56	
17	75000	190×90×90	17100	4.39	
18	85000	190×90×90	17100	4.97	5.03
19	95000	190×90×90	17100	5.56	
20	80000	190×90×90	17100	4.68	

Table3- Observations & Calculation of compressive strength

H. Finite Element Method

The finite element method (FEM) (its practical application often known as finite element analysis (FEA)) is a numerical technique for finding approximate solution of partial differential equation (PDE) as well as integral equation. The solution approach is based either on eliminating the differential equation completely (steady state problem), or rendering the PDE into an approximation system of ordinary differential equation, which are then numerically integrated using standard technique such as Euler's method , Rungekutta, etc.

Brick type	Young`s modulus E in MPa	Poission's ratio
Ordinary brick	7000	0.15
50 red mud+50 fly ash	11501	0.345
60 red mud+40 fly ash	9201.1	0.344
70red mud+30 fly ash	6901.1	0.343
80 red mud+20 fly ash	4601.4	0.342
90red mud+10 fly ash	2301.6	0.341

Table 4- Material property of bricks

I. Analysis Results For Brick Geometry

With the help of ANALYSIS result obtained for case brick geometry, we can observe that Poisson ratio and young modulus in Normal bricks Length of Brick =190 mm Width of Brick = 90 mm Height of Brick= 90 mm Hole Dia. = 25 mm In normal bricks, composition value with Poisson ratio 0.15 and young modulus 70000 MPa the applied the load 90,000 N then displacement of bricks 0.069297mm and compressive stress 5.185MPa.

J. Finally Compare Results And Analysis With FEM

Generally water absorption of ordinary brick of size 190x90x90(mm) range from 10% to 12%. It's hence in the trail I to IV water absorption average 14.11% and hence to max water absorption 11%.If the red mud quantity are more mixing of block than the found water absorption are increase v/s ordinary bricks. Generally compressive strength of ordinary brick of size 190x90x90(mm) range from 5mpa. It's hence in the trail I to IV compressive strength average 5.11mpa and hence to max compressive strength 4mpa.If the red mud quantity are more mixing of block than the found compressive strength are increase v/s ordinary bricks.

K. Conclusion

In the present thesis work of experimental study was done on manufacturing and testing of bricks using red mud. Hence as per test and results of the study following points can we recommend on the properties of red mud bricks.

Red mud +fly ash brick is having the lowest water absorption and highest compressive strength.

Red +fly ash brick is having the water absorption of 12%.

Fly ash +clay bricks are having the highest water absorption.

Among the curing condition studied water cured bricks have shown higher compressive strength.

Among the various systems studied red mud based bricks have shown higher compressive strength.

Among the curing periods studies 28 days curing period had shown the highest compressive strength.

Saving of 50% of clay, which are very important materials.

Cly materials are the agriculture used.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Environmental saving.

Recycling of waste material, total disposal for water soil.

Potential problem solve, 0.5 mm saving of clay.

Jute / sisal fibre reinforced red mud/fly ash/ marble slurry dust.

Cement Kg/m3	Red Mud Kg/m3	T.Cement-ious content Kg/m3	Water litres	W/(C+FA)	Fine Agg. Kg/m3	CA<20 mm Kg/m3	CA<10 mm Kg/m3	Slump mm	CS 7days MPa	CS 28day-s MPa
235	-	235	153.0	.65	703.27	783.65	522.43	100	20.5	36.0
280	-	280	163.0	.58	677.87	755.34	503.56	90	28.0	41.5
196	84	280	157.5	.56	673.37	750.33	500.22	100	18.0	36.0
210	90	300	160.0	.53	663.95	739.83	493.22	100	20.5	39.0
180	120	300	156.0	.52	664.07	739.96	493.31	95	19.0	35.0

Table5- Trial Mix Design of M20 Grade Concrete with Red Mud

Cement Kg/m3	Red Mud Kg/m3	T.Cementious content Kg/m3	Water litres	W/(C+FA)	Fine Agg. Kg/m3	CA<20 mm Kg/m3	CA<10 mm Kg/m3	Slump mm	Density Kg/m3	Setting time (Hrs.min.) Initial/Final
235	-	235	143.0	0.61	703.27	783.65	522.43	80	2350	5.45 7.15
196	84	280	150.5	0.54	673.37	750.33	500.22	80	2365	7.15 8.25
180	120	300	152.0	0.51	664.07	739.96	493.31	80	2355	8.5 10.25

Table6- Mix Design 0f M20 Grade Concrete with Red Mud

IV. RESULT

Comparison for normal P.C.C (M20) red mud admixed concrete and fly ash admixed concrete:

Sr. No.	Comparison parameters	P.C.C concrete	Red mud admixed concrete	Flyash replaced concrete
1	Compressive strength	20 MPa	29.12 Mpa	33 Mpa
2	Flexural strength	1.8 Mpa	4.8 Mpa	3.8 MPa
3	Cost	Costlier than red mud admixed and fly ash admixed concrete.	Less costlier	Less costlier

4	Colour	Grey	Imparts brownish colour	Light grey
5	Impact on environment	Creates environmental pollution	Prevents environmental pollution	Prevents environmental pollution
6	Resistance to cracking	Less than red mud admixed and fly ash admixed concrete.	High resistance to cracking	High resistance to cracking
7	Permeability	22.4%	18.32%	19.5%
8	Resistance to corrosion	Lesser than red mud admixed and fly ash admixed concrete.	Imparts high resistance to corrosion.	Imparts high resistance to corrosion.
9	Durability	Lesser than red mud admixed and fly ash admixed concrete.	Higher	Higher
10	Long ability	Lesser than red mud admixed and fly ash admixed concrete.	Higher	Higher

Table 7: Red mud admixed concrete and fly ash admixed concrete comparison for M20 Grade concrete
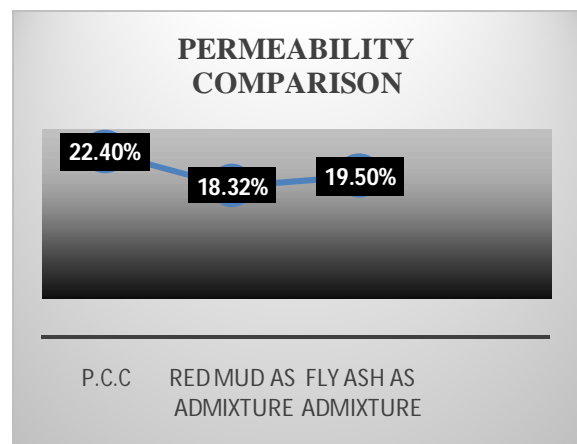
Fig 1- Permeability comparison
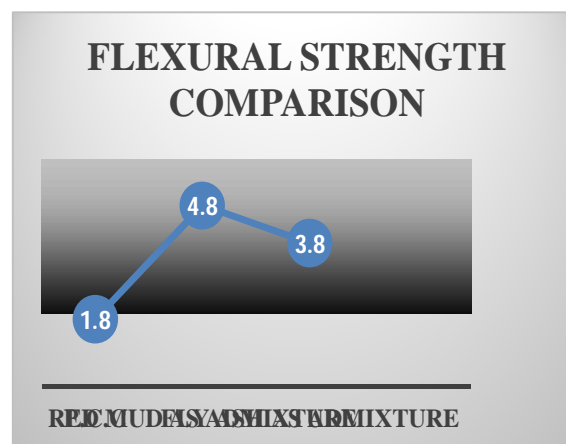
Fig 2- Flexural strength comparison
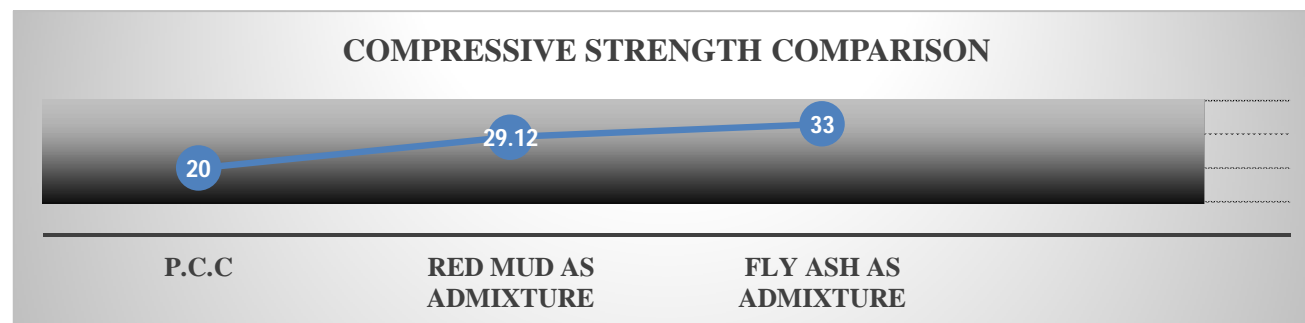
Fig -3 Compressive strength comparison

V. CONCLUSION AND FUTURE SCOPE

A. Conclusion

From the above discussion we can come to the conclusion that red mud on being replaced with cement improves its mechanical

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

properties and proves to be economical. On the basis of literature survey, it is evident that red mud serves as a good binder material and has proved to be a good cementations material. Red mud reduces the capillary pores of concrete and hence as the percentage of red mud in concrete increases there is a consequent decrease in the percentage of water absorbed. Red mud contains components that in combination with lime produce calcium aluminates hydrates. These reaction products are able to develop strength. Thus for the purpose of economical construction and for increasing the mechanical properties of concrete red mud has proved to be effective in all respects.

A simple mixing of 70% red mud and 30% CaO gives a product with compressive strength of 7MPa. The hydrates formed after 4 days are Ca $(OH)_2$ C_4AH_{13} and C_4AH_{11}.by addition of 10% gypsum a compressive strength of 15 MPa is obtained after 7 days.

At later ages, etteringite expansion will occur. These results have been confirmed by more recent experiments. Cements prepared by mixing red mud with and or portlandite show a decrease of the flexural strength as function of time. Red mud does not impart much compressive strength when compared to fly ash, but it has been observed that flexural strength and resistance to permeability increases in red mud cement concrete. Although using red mud is less feasible than using fly ash but it is necessary to use or recycle red mud as it has many harmful environmental effects.

B. Future Scope

As replacing with cement with red mud yielded satisfactory results of mechanical properties of concrete so it can be used in different proportions and can be used for mass concreting. Literatures revealed that along with red mud if 10% Gypsum is added then there would be much more increase in strength. This project can continue for further researches because as per our project red mud is applicable for non-structural members, so research can be done whether red mud is suitable for structural members or not.

Red mud can be used along with other admixtures like fly ash, glass fibre and other thermoplastic polymer like polypropylene fibre in concrete technology and the results obtained on the test performed on mechanical properties can be tested.

REFERENCES

[1]   S. S. Amritphale, A. Anshul, N. Chandra, and N. Ramakrishnan,"A novel process for making radiopaque materials using bauxite-Red mud," Journal of the European Ceramic Society,vol. 27, no. 4, pp. 1945–1951, 2007.

[2]   E. Kalkan, "Utilization of red mud as a stabilization material for the preparation of clay liners," Engineering Geology, vol. 87, no. 3-4, pp. 220–229, 2006.

[3]   P. Asokan, M. Saxena, and S. R. Asolekar, "Coal combustion residues—environmental implications and recycling potentials," Resources, Conservation and Recycling, vol. 43, no. 3, pp. 239–262, 2005.

[4]   M. Patel, "Utilisation of red mud, fly ash for manufacturing bricks with propylite," Silicates Industrials, vol. 2, pp. 31–35, 1987.

[5]   V. M. Sglavo, S. Maurina, A. Conci, A. Salviati, G. Carturan, and G. Cocco, "Bauxite 'red mud' in the ceramic industry. Part ISRN Materials Science 11 2: production of clay-based ceramics," Journal of the European Ceramic Society, vol. 20, no. 3, pp. 245–252, 2000

[6]   N. Yalc ̦in and V. Sevinc ̧, "Utilization of bauxite waste in ceramic glazes," Ceramics International, vol. 26, no. 5, pp. 485– 493, 2000.

[7]   P. E. Tsakiridis, S. Agatzini-Leonardou, and P. Oustadakis, "Red mud addition in the raw meal for the production of Portland cement clinker," Journal of Hazardous Materials, vol. 116, no. 1-2, pp. 103–110, 2004.

[8]   M. Singh, S. N. Upadhayay, and P. M. Prasad, "Preparation of iron rich cements using red mud," Cement and Concrete Research, vol. 27, no. 7, pp. 1037–1046, 1997.

[9]   M. F. Montemor, A. M. P. Simoes, and M. G. S. Ferreira, "Chloride-induced corrosion on reinforcing steel: from the fundamentals to the monitoring techniques," Cement and Concrete Composites, vol. 25, no. 4-5, pp. 491–502, 2003.

[10]   S. Wolynec, Tecnicas Eletroq Uımicasem Corrosao, EDUSP, Sao Paulo, Brazil, 1st edition, 2003.

[11]   B. J. Christensen, R. T. Coverdale, R. A. Olson et al., "Impedance spectroscopy of hydrating cement-based materials: measurement, interpretation, and application," Journal of the American Ceramic Society, vol. 77, no. 11, pp. 2789–2804, 1994.

[12]   B. J. Christensen, T. O.Mason, and H.M. Jennings, "Influence of silica fume on the early hydration of Portland cements using impedance spectroscopy," Journal of the American Ceramic Society, vol. 75, pp. 939–945, 1992.

[13]   J. J. Vermoyal, A. Frichet, L. Dessemond, and A. Hammou, "AC impedance study of corrosion films formed on zirconium based alloys," Electrochimica Acta, vol. 45, no. 7, pp. 1039– 1048, 1999.

[14]   L. F. Maia and A. C. M. Rodrigues, "Electrical conductivity and relaxation frequency of lithium borosilicate glasses," Solid State Ionics, vol. 168, no. 1-2, pp. 87–92, 2004.

[15]   R. T. Coverdale, R. A. Olson, B. J. Christensen et al., "Interpretation of the impedance spectroscopy of cement paste via computer modelling—part III: micro structural analysis of frozen cement paste," Journal of Materials Science, vol. 30, no. 20, pp. 5078–5086, 1995.

[16]   Daniel Véras Ribeiroa, Joao Antonio Labrinchab, Marico Raymundo Morellia. Potential Use of Natural Red Mud as Pozzolana for Portland cement. Materials Research. 2011; 14(1): 60-66

[17]   L. Senff, D. Hotza, J.A. Labrincha .Effect of red mud addition on the rheological behavior and on hardened state characteristics of cement mortars.

[18]   P.E. Tsakiridis, S. Agatzini-Leonardou, P. Oustadakis .Red mud addition in the raw meal for the production of Portland cement clinker. Journal of Hazardous Materials B116 (2004) 103–110

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)