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Experimental Study on Concrete with Bauxite Residue as Partial Replacement of Cement

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Abstract : Environment is getting worse in the present scenario and one of the causes is due to the industrial pollution and its waste. In this developing world, metal production especially aluminium is the most demanding material for manufacturing electronics, preservation of food by foils, containers, constructions purposes and so on. To make 1 ton of aluminium 2 tons of bauxite ore is required and is extracted by Bayer's process. The by-product called as red mud or red sludge. In India, there are about 3 billion tonnes bauxite reserves and is producing 4 million tonnes of red sludge as side product annually[5,8]. It contains ferric oxide, aluminium oxide and silicon dioxide as major constituents. Due to its presence in highly caustic content, it is unable to utilise in an alternative way and is dumped in large landfills[3,7]. So,by taking advantage of the cementitious property of this industrial waste, trials had been carried out to find the optimum usage of red sludge in concrete which is done by replacing in some percentages with cement.

Keywords : red mud, red sludge, bauxite residue, Industrial waste, red mud concrete, compressive strength.

1.0 Introduction

Red sludge is a hazardous waste produced in the mining industry and is experiencing serious disposal problems as it is highly alkaline composed mainly of iron oxide[2,4]. There are some attempts made in production of brick, ceramic products like tiles, glazes, red mud polymer composites panels as substitute for wood, iron rich cement etc..,. for partial substitute but none of them proven economically satisfactory.

With the use of red sludge as a partial replacement for cement makes concrete attain more strength than usual. Due to the contents of aluminium oxide and ferric oxide in the red sludge causes the bonding in concrete stronger while adding in some percentages.

Thus, an experiment is carried out to find the optimum usage of red sludge as a partial replacement of cement and not only use this non-eco-friendly material to reduce the storage area for dumping but also protect from the contamination of ground water.

2.0 Experimenting Red Sludge as Cement Replacement

2.1 Materials Used:

2.1.1 Properties of Red Sludge:

The geotechnical properties of red sludge which we had obtained from Vedanta aluminium smelter, Jharsuguda located in Orissa is given as follows.

Specific Gravity : 2.6
Maximum dry density : 1.169 gm/cm^3
Optimum moisture content : 25.6 %

Grain Size Distribution:

Clay – 21%
Silt – 70%
Sand size – 9%

Chemical Composition:

Chemical Name	Percentage
Ferric Oxide (Fe_2O_3)	61
Silicon dioxide (SiO_2)	17
Aluminium Oxide (Al_2O_3)	15
Titanium dioxide (TiO_2)	4
Sodium Oxide (Na_2O)	4
Calcium Oxide (CaO)	1
Loss of ignition	7

2.1.2 Cement

As per code IS: 269-1976, Ordinary Portland Cement (Ramco OPC 53 Grade) was used for the entire experiment. The physical properties and tests where done to meet the standards as per IS: 4031-1968.

Physical Properties of OPC 53 Grade:

S.no.	Characteristics	Values
1	Standard Consistency	33
2	Fineness of cement as retained on 90 microns sieve	3 %
3	Initial Setting Time	30 mins
4	Specific Gravity	3.15
5	7 days' compressive strength	23 Mpa

Chemical Properties of Cement:

S.no	Components	Weight
1	Lime (CaO)	63%
2	Silica (SiO_2)	22%
3	Alumina (Al_2O_3)	6%
4	Iron oxide (Fe_2O_3)	3%
5	Magnesium oxide (MgO)	2.5%
6	Sulphur trioxide & loss of ignition (SO_3)	1.5%
7	Alkalis	0.5%

2.1.3 Aggregates

Stone crusher with 20 mm as maximum size and specific gravity as 2.74 of coarse aggregate is used for this investigation. For fine aggregate, Manufacturing Sand is used with specific gravity of 2.73 (Zone II) confirming IS383 recommendations.

2.1.4 Water

Clean water is used for all purpose like red sludge washing, casting and curing of specimen. The requirements of water quality are as expected in Indian Standard requirements such as it is free from oil, silt, sugar, organic matters, chloride and acidic.

2.1.5 Admixture

The BASF's Naphthalin based admixture is added to the concrete named as Rheobuild 922 CC. It gives workability, strength, quality, good slump return strength and is also chloride free.

Structure of the material	**Naphthalene sulphonate based**
Colour	Brown
Density	1.142 – 1.202 kg/liter
Chloride content %	< 0.1
Alkaline content %	< 10

2.2 Red Sludge Washing:

Due to the presence of caustic soda in the red sludge, the pH ranges from 12-13. To minimise the pH level in it, washing the red sludge in water for 4-5 times reduces the pH level, which will bebetween 8-9. By adding diluted ammonia (1N) during the 3rd wash, the caustic soda is removed easily and finally the results are tested using a pH indicator. The red sludge is dried before utilising it in concrete.The pH testing results with the pH paper and the pH scale is as follows.





2.3 Mixing Grade & Ratio for Concrete:

The mixing ratio is prepared for M30 withred sludge replacement as 5%, 10%, 15%, 20% with OPC 53 Grade as well as the control concrete. The cube is casted in 150 mm x 150 mm x 150 mm moulds for all 5 mixes and each mix is casted in 9 moulds.

Mix Proportions

For all trial mixes the following materials remain the same.

Fine Aggregate kg/m^3	**Coarse Aggregate kg/m^3**		**Total Water kg/m^3**	**Admixture 96kg/m^3**
	20 mm	**12.5 mm**		
340	760	411	196	2.40

The cement and red sludge mixes are as follows:

Mixes	**Cement kg/m^3**	**Red Mud Kg/m^3**
Mix 1 (0 %)	340	0
Mix 2 (5 %)	323	17
Mix 3 (10 %)	306	34
Mix 4 (15 %)	289	51
Mix 5 (20 %)	272	68

2.4 Compressive strength:

The compressive strength is checked in a digital compressive testing machine for more accuracy on the 7th, 14th, and 28th day from the day of curing.

Compressive Strength In 7 Days

Percentage of Red mud replacement with cement	Weight of cube	Peak load (MPa)	Peak Stress (KN)
Control Concrete	8.186	633	28.13
5%	8.188	648.5	28.83
10%	8.236	570	25.56
15%	8.213	528	23.46

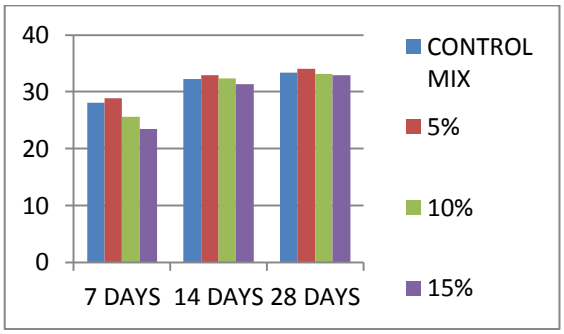
Compressive Strength in 14 Days

Percentage of Red mud replacement with cement	Weight of cube	Peak load (MPa)	Peak Stress (KN)
Control Concrete	8.295	726	32.26
5%	8.233	733.25	32.96
10%	8.228	728.25	32.36
15%	8.282	705.75	31.36

Compressive Strength In 28 Days

Percentage of Red mud replacement with cement	Weight of cube	Peak load (MPa)	Peak Stress (KN)
Control Concrete	8.316	743	33.43
5%	8.288	749.5	34.06
10%	8.276	732	33.14
15%	8.283	714.25	32.95

Graph Showing the Variation of Compressive Strength Checks



2.5 Workability

Due to the addition of red sludge, it absorbs more water than cement and causes the mix less workable. So, by adding admixtures we can maintain the regular workability and able to create good results. If water is added instead of admixture, then there are chances of losing the lateral strength.

3.0 Conclusion

- The compressive strength test shows the early and lateral days' strength attained in 5 % is higher than 10 % and 15 % replacement of red sludge with cement.
- Increasing the replacement of red sludge reduces the strength of concrete and optimum replacement should be 5 to 10 percentage.
- due to the higher content of ferric oxide in
- Washing of red sludge for neutralisation with the 1N ammonia solution removes the sodium oxide content which has produced better strength and durability when compared with replacing red sludgedirectly with cement.
- Water consumption during the curing days is increased due to presence of red sludge.
- Due to addition of naphthalene based admixture the slump is well maintained.
- Workability and strength of the concrete also increased due to addition of admixture.
- The following pros and cons have been arrived though this experiment.

3.1 Advantages

- Usage of this non-eco-friendly material in concrete not only adds strength to the concrete but also reduces the accumulation of this hazardous material when consumed.
- The Cement replacement reduces and hence the cost of it is ultimately brought down by the percentage of replacement.
- Addition of hydrated lime will create more strength than the usual which can lead to increased replacement levels without losing its original strength.
- The recent aluminium separation process reduces the usage of caustic soda and hence the washing of red sludge for reducing pH level is easier.

3.2 Disadvantages

- The colour of the concrete is changed due to the presence of ferric oxide and hence commercialising or handling with bare hands is difficult.
- It creates an itching sensation when handled without gloves as it is alkaline and may also cause boils when hand is kept unwashed for longer period.
- Washing of red sludge should be done in order to remove the presence of caustic soda and large scale implementation is harder.
- Due to the presence of higher content of ferric oxide, red sludge concrete cannot be used in RCC structures

4.0 References

1. Mohan Khushwaha, Dr.SalimAkhtar, Survesh Rajput, 'Development of Self Compacting Concrete by Industrial Waste (Red mud)', International Journal of Engineering Research & Applications (IJERA), Vol-3, Issue-4, July-Aug 2013, pp 539-542 [2] A.B. Sawant, M.B. Kumthekar, V.V. Diwan, K.G. Hiraskar,
2. 'Experimental Study on Partial Replacement of Cement by Neutralized Red mud in Concrete', International Journal Of Engineering & Advance Technology (IJEAT), Volume-2, Issue-1, oct-2012
3. Abhishek HN and M.U.Aswath, "Strength Studies of Red Mud Based Geopolymer Concrete", International Journal of Emerging Trends in Engineering and Development, vol. 6, Issue. 2, 2012.

4. Daniel VerasRibeiroa, Joao Antonio Labrinchab, MarcioRaymundoMorellia,"Potential Use of Natural Red Mud as Pozzolan for Portland Cement", Journal of Materials Research, vol. 14, pp. 6066, 2011.
5. Daniel VerasRibeiroa, Joao Antonio Labrinchab, MarcioRaymundoMorellia,"Potential Use of Natural Red Mud as Pozzolan for Portland Cement", Journal of Materials Research, vol. 14, pp. 6066, 2011.
6. Daniel VerasRibeiroa, Joao Antonio Labrinchab, MarcioRaymundoMorellia,"Potential Use of Natural Red Mud as Pozzolan for Portland Cement", Journal of Materials Research, vol. 14, pp. 6066, 2011.
7. 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.
8. K. Snars, R.J. Gilkes, Evaluation of bauxite residues (red muds) of different origins for environmental applications, Applied Clay Science, 2009, article in press: doi:10.1016 /j. clay.2009.06.014.

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