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Study of Effect of Red Mud on the Properties of Concrete

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***Abstract*— In India and worldwide, variety of waste is generated in different forms, shape and texture. These industrial wastes mostly possess threat to the environment and the society living nearby. Various researches has been done on this waste material to either degrade or to utilize it in some or the other way. One such hazardous waste generated by industry is Red mud. It is the residual waste generated by Bayer's Process of aluminum extraction. Red mud is the most hazardous waste than the other waste mainly due to its high fineness and Ph. Steps have been taken to utilize this waste as partial replacement of cement in concrete without compromising the strength and economy. For this mortar cubes were casted using cement with varying percentage of red mud with the addition of lime and the same procedure followed for silica to find the optimum red mud replacement with addition of either lime or silica. After this test result showed that 10% red mud replacement with 20% silica to the weight of red mud can be added effectively in concrete without compromising the strength and also decreasing the cost of cement in concrete by 6.43% thereby achieving economy. This paper also speaks about the future possibilities of using red mud as a partial replacement in concrete for work such as buildings, pavements, dams, etc after few more test is conducted and various other parameters found on this optimized concrete.**

***Keywords*— Cement mortars, concrete, lime, silica fume, compressive strength, tensile strength.**

I. INTRODUCTION

Today, the utilization of cement in India and around the world is so much that it is on the verge of extinction and also creating numerous environmental problems after its use. Simultaneously there is an increase in generation of industrial waste such as fly ash, red mud, rice husk ash, etc in developing and developed countries. There is a great problem around the world regarding the decomposition of waste as it neither is non-decomposable nor can be utilized for the benefit of human life to its fullest. Only possible way to dispose is to dump on barren lands or to use in construction industry. Hence various researches have been done and are going on to make it utilized in construction industry.

One such industrial waste is Red Mud. It is generated in aluminum production by the Bayer's Process and is considered Hazardous due to its high Ph of 12.5. It is generated of the order of 142 million tons per year in the world. There is a need to utilize this waste. In this work attempt has been made to use red mud as a partial substitute of cement to its full extent by adding admixtures such as lime and silica. Since huge quantities of concrete are used in construction such as pavement in today's context, it has been tried to utilize this waste in the construction industry with optimum lime or silica use in it without compromising the strength.

II. PROPERTIES OF RED MUD

A. Physical properties of red mud

- Fineness-in between 10-30 m^2/g, Red mud is very fined grained material.
- It's Ph -10.5 to 12.5.
- Specific gravity of red mud 2.51

B. Chemical properties of red mud

The table below shows the chemical properties of red mud given by HINDALCO Ind. Ltd, Belgavi, Karnataka.

Table 1
Chemical 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%

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C. Effects of red mud on environment

- *Ground water pollution:* when the red mud get mix with surface water ,alkalinity of water increases .If service reservoirs will get polluted it may create hurdles to society.
- Alkali seepage in to underground water-Underground water resources such as wells, aquifer may get polluted.
- The fertility of the land gets reduced when this waste gets mixed with fertile land.
- Huge area of land is consumed for dumping of Red mud.

D. Literature Review

The result from the various researchers around the globe says that the mechanical strength decreases with increasing percentage of red mud in concrete.[3] It also speaks that SiO_2 & Al_2O_3 might be responsible for the cementetious activity in concrete.[3] The result from one of paper say that the red mud can be used up to 4% replacement in concrete without compromising its strength.[1] It also says that 2% red mud can be substituted in self compacted concrete resulting in slight increase of strength.[1] One of the journals from Brazil says that the electrical resistivity increases with increase in red mud content in concrete.[8]

Also, the corrosion rate decreases with increases in red mud content. [8] Another author from Chalmers University of technology, China says that the red mud does not contribute to the strength; rather it acts as filler in concrete. The decrease in compressive strength with the addition of red mud is mainly due to increase water cement ratio. He suggests the addition of Silica fume with red mud in concrete. [6]

III. Objectives Of Work

This project is based on ascertaining the suitability of red mud to replace cement partially to overcome the problems created due red mud and minimize the thrust of Industrial waste on the environment by utilizing the same in the Construction Industry.

Following are primary objectives of the project.

1. To find the optimum cement replacement by red mud with the addition of lime or silica by casting mortar cubes.
2. To estimate the optimized replacement of cement with red mud using lime or silica in the concrete without compromising the designed strength compressive and tensile strength of controlled cement concrete.
3. To analyze the economy of the optimized red mud concrete by comparing it with controlled concrete.

IV. Experimental Procedure

First, mortar cubes with by varying red mud replacement such as 0%, 10%, 15%, 20%and 25% with addition of 0%, 4%, 8% and 12% lime to the weight of red mud was casted and 7 day compressive strength was taken in UTM following the respective IS. Then mortar cubes with by varying red mud replacement such as 0%, 10%, 15%, and 20% with addition of 0%, 10% and 20% lime to the weight of red mud was casted and 7 day compressive strength was taken and these result were analyzed to get the optimum red mud content. After this, control concrete cubes and cylinders was casted for M30 grade concrete using only cement having ratio 0.553: 1: 2.325: 2.87 by following the mixed design procedure for concrete and tested it for 28 days strength. Then the concrete cubes and cylinders of optimized red mud with addition of lime or silica were casted and tested for 28 days and 90 days strength and compared it with the controlled concrete. Also, cost analysis of this optimised concrete was performed

V. Results

The table below shows results of the test performed on red mud with the addition of lime and silica content.

A. Optimum red mud content using lime

1.Using 10% red mud with varying lime content

The table below shows the obtained result of 10% Red mud with varying percentage such as 0%, 4%, 8% & 12% lime addition to the weight of Red mud.

Table 2
Results of 10% red mud with varying % of lime content

Grade of mortar	% red mud Used	% Lime used	7 days average Compressive Strength (N/mm^2)
53 grade	10%	0%	32.19
		4%	34.14
		8%	29.16
		12%	28.73

2. Using 15% red mud with varying lime content

The table below shows the obtained result of 15% Red mud with varying percentage such as 0%, 4%, 8% & 12% lime addition to the weight of Red mud.

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Table 3
Results of 15% red mud with varying % of lime content

Grade of mortar	% red mud Used	% Lime used	7 days average Compressive Strength (N/mm^2)
53 grade	15%	0%	31.27
		4%	32.1
		8%	28.52
		12%	29.55

3.Using 20% red mud with varying lime content

The table below shows the obtained result of 20% Red mud with varying percentage such as 0%, 4%, 8% & 12% lime addition to the weight of Red mud.

Table 4
Results of 20% red mud with varying % of lime content

Grade of mortar	% red mud Used	% Lime used	7 days average Compressive Strength (N/mm^2)
53 grade	20%	0%	24.44
		4%	27.79
		8%	26.00
		12%	26.37

4.Using 25% red mud with varying lime content

The table below shows the obtained result of 25% Red mud with varying percentage such as 0%, 4%, 8% & 12% lime addition to the weight of Red mud.

Table 5
Results of 25% red mud with varying % of lime content

Grade of mortar	% red mud Used	% Lime used	7 days average Compressive Strength (N/mm^2)
53 grade	25%	0%	20.97
		4%	23.85
		8%	21.66
		12%	22.08

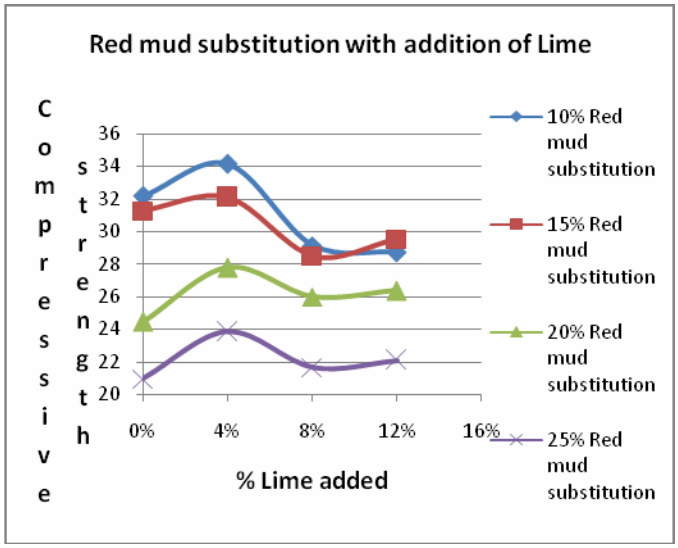

Figure 1 Compressive strength of mortar cubes with varying percentage of red mud with varying percentage of addition of lime

B. Optimum red mud content using silica fume

1.Using 10% red mud with varying silica fume content

The table below shows the obtained result of 10% Red mud with varying percentage such as 0%,10% % 20% addition to the weight of Red mud.

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Table 6
Results of 10% red mud with varying % of Silica content

Grade of mortar	% red mud Used	% Silica used	7 days average Compressive Strength (N/mm2)
53 grade	10%	0%	32.19
		10%	34.07
		20%	35.41

2.Using 15% red mud with varying silica fume content

The table below shows the obtained result of 15% Red mud with varying percentage such as 0%,10% % 20% addition to the weight of Red mud.

Table 7
Results of 15% red mud with varying % of Silica content

Grade of mortar	% red mud Used	% Silica used	7 days average Compressive Strength (N/mm2)
53 grade	15%	0%	31.27
		10%	31.61
		20%	32.60

3.Using 20% red mud with varying silica fume content

The table below shows the obtained result of 20% Red mud with varying percentage such as 0%,10% % 20% addition to the weight of Red mud.

Table 8
Results of 20% red mud with varying % of Silica content

Grade of mortar	% red mud Used	% Silica used	7 days average Compressive Strength (N/mm2)
53 grade	20%	0%	24.44
		10%	26.81
		20%	32.23

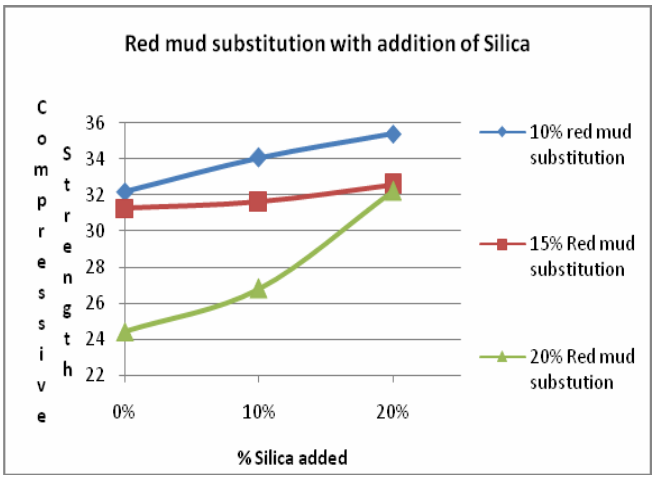

Figure 2 Compressive strength of mortar cubes with varying percentage of red mud with varying percentage of addition of Silica fume

From the above two graph, there was a clear indication that the strength of 10% Red mud with 20% silica addition to the weight of Red mud mortar was equivalent to the strength of the cement mortar. Hence, it can be said that this content of red mud with silica is the optimum content for cement substitution in mortar or concrete.

C. Structural properties of optimized concrete

In this section, attempts were made to get mix design of controlled concrete for M30 grade and substituting the optimized red mud content with addition of silica in the same mix design keeping other materials such as sand and coarse aggregate constant for the optimum concrete and thereby comparing both of them for compressive and tensile strength. The mix design obtained was 0.553: 1: 2.325: 2.87. The strength of controlled concrete was taken for 28 days and that for optimized concrete was taken for 28 days and 90 days.

Table 9
Comparison between controlled & Optimum concrete

Type of concrete/ Parameter	Controlled concrete for 28 days	Optimum concrete for 28 days	Optimum concrete for 90 days
Compressive strength	39.60	41.46	44.57
Tensile strength	4.31	3.95	4.16

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D. Cost analysis

Cost of cement from the obtained control mix design for 1 m^3 and the cost of optimized concrete for the same volume were compared to know the difference in the cost of these two concrete keeping sand and coarse aggregate constant for both concrete.

Table 10
Cost analysis of the optimized concrete

	Cost in Rs for 1 m^3 concrete			
Silica content	**100% cement**	**10% redmud**	**15% redmud**	**20% redmud**
0%	2520	2268	2142	2016
10%	-	2358	2277	2196
20%	-	**2448**	2412	2376
30%	-	2538	2547	2556
40%	-	2628	2628	2736

VI. CONCLUSION

Following were the conclusion drawn from the experimental work carried out. They are as stated below:

1. The result shows that the strength increases slightly for 4% Lime addition and there after strength decreases with increase in lime content. This can be explained by that the lime added may react with free reactive silica present in red mud and when the Silica gets exhausted, the extra lime added might have reacted with Alumina forming Calcium Aluminates ($CaO.Al_2O_3$) leading to more initial heat of hydration and thereby generating pores leading to decreased strength.
2. The result gives that addition of silica enhances strength of mortar and for 10% red mud with 20% silica of red mud addition gives the same strength as that of only cement. Hence, it can concluded that 10% red mud can be utilized with addition of 20% Silica of Red mud without compromising the strength of Mortar and Concrete respectively.
3. From the above two results it shows that compressive strength of the optimum red mud concrete increases by 4.6% and the tensile strength decreases by 8%. Overall it can be concluded that the results obtained for optimum red mud content shows that concrete can be used for R.C.C work after finding of other essential parameters of optimized concrete.
4. There is saving of 6.43% in cement cost by using optimum red mud concrete using silica per m^3 of concrete.

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