International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 06 | June -2017 www.irjet.net p-ISSN: 2395-0072

EXPERIMENTAL STUDY ON UTILIZATION OF RED MUD AND USED FOUNDRY SAND IN CEMENT CONCRETE

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ABSTRACT: *The aim of the work is to investigate the possibility of replacing the part of Portland cement by Red mud and Fine Aggregates by Used foundry sand. Because of storing issues, the waste negatively affects the environment. To solve this problem, an attempt was made to check the effectiveness of Red mud as a partial replacement of Portland cement. Portland cement was replaced up to 30 % Red mud by the weight of cement and checking the compressive strength of mortar. Fine aggregate was replaced up to 60% Used foundry sand and evaluating its compressive and split tensile strength of Red mud concrete. The optimum gained after 7 and 28 days curing period was found to be 20% Red mud (for mortar) and for the combination of both Red mud and Used foundry sand was found to be 20% Red mud + 40% Used foundry sand(for concrete).*

Key Words*: Red mud, Used Foundry sand*

I. INTRODUCTION

The modern trend in Civil Engineering is at achieving the designed character at the minimum cost, yet not sacrificing the usefulness of the project. The production of cement is very essential for the development of countries economy. The current demand for cement in our country is far in excess of production and is rapidly increasing. Despite large and rising demand for cement it has been difficult to start up big cement plants in recent years, mainly because of the requirement of large increment and long gestation period. Nowadays, the search for recycling alternatives of several industrial wastes or by- products is a common practice, conducted under legislation pressure but also attempting to eliminate cost of disposal and to avoid soil and water contamination. The current trend all over the world is to utilize the treated and untreated industrial by-products as a raw material in concrete, which gives an eco-friendly edge to the concrete preparation process.

In India, there is great demand of aggregates mainly from civil engineering industry for road and concrete constructions. But nowadays it is very difficult problem for available of fine aggregates. So researchers developed waste management strategies to apply for replacement of fine aggregates for specific need. Natural resources are depleting worldwide while at the same time the generated wastes from the industry are increasing substantially. The sustainable development for construction involves the use of nonconventional and innovative materials, and recycling of waste materials in order to compensate the lack of natural resources and to find alternative ways conserving the environment.

1.1 Red Mud

Red mud is an aluminium industrial waste product which is red in colour. Its characteristics depends on the nature of bauxite ore used in the extraction of aluminium which slightly differ from place to place, out of which 4.5 tones of bauxite 1.0 tones of aluminium is extracted and 2/3rd will be the waste product. This red mud (alumina waste) is used in concrete for partial replacement of cement without sacrificing the quality and the desired strength. As to the resource utilization of red mud, alumina companies have been carrying out many technical researches on production of construction material, especially cement production and glass production, production of filling material for plastic, production of road base. And they have made some progress, especially in the production of cement using red mud.

Table 1: Chemical Composition of Red mud

Chemical composition	Bauxite residue	Typical values world wide
Fe_2O_3	45	30-60
Al_2O_3	15	10-20
CaO	4	2-8
SiO_2	8	03-50
NaO	5	02-10
Tio_2	10	Traces -25%
Traces of LOI	10	10-14

1.1.1 Effect of red mud on environment

In the last decade, the production of aluminium in spite of some stagnancy and set back periods has shown a steady rise of about 1%. Red mud is disposed as dry or semi dry material in red mud pond or abandoned bauxite mines and as slurry having a high solid concentration of 30-60% and with a high ionic strength. The environmental concerns relate to two aspects: very large quantity of the red mud generated and its causticity.

Problems associated with the disposal of red mud waste include:

•Its high pH (10.5-12.5)
•Alkali seepage into underground water Instability of storage.
•Alkaline air borne dust impact on plant life vast areas of land consumed.
•Ground water pollution-when the red mud gets mix with water.

1.2 Used Foundry sand

Used Foundry sand is a by-product of the castings industry typically comprising uniformly sized sands with various additives and metals associated with the specific casting process. Most metal casting sand (FS) is high quality silica sand with uniform physical characteristics. It is a by-product of the ferrous and nonferrous metal casting industry, where sand has been used for centuries as a molding material because of its unique engineering properties. In modern foundry practice, sand is typically recycled and reused through many production cycles. Industry estimates are that approximately 100 million tons of sand are used in production annually. Of that, four (4) to seven (7) million tons are discarded annually and are available to be recycled into other products and industries.

Uses of Foundry Sand

- Foundry sand used for the centuries as a molding casting material because it's high thermal conductivity.
- The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates.
- Foundry sand can be used in concrete to improve its strength and other durability factors.

Table 2: Chemical Composition of Used Foundry sand

Sl. No	Chemical Compounds	% of compounds
1	SiO_2	87.91
2	Al_2O_3	4.70
3	Fe_2O_3	0.94
4	CaO	0.14
5	MgO	0.30
6	SO_3	0.09
7	Na_2O	0.19
8	K_2O	0.25
9	TiO_2	0.15
10	P_2O_5	0.01
11	Mn_2O_3	0.02
12	SrO	0.03

II.OBJECTIVES OF WORK

Basically this paper is based on the dissertation work carried out to overcome the problems created due exhaustion and obsolescence of raw material required for manufacturing of conventional building material and also minimize the thrust of Indusial waste on the environment by utilizing the same in the Construction Industry.
Based on the literature review the following are the objectives of present work.

1. To Investigate the Utilization of Red mud as Supplementary Cementitious Material (SCM) and influence of this Red mud on the Compressive Strength of mortar.
2. To Study the Effect of Red mud (Replacement to cement) & used foundry sand (Replacement to Fine Aggregate) on Strength Parameters of concrete.
3. The use of industrial wastes in place of conventional raw materials will help to decrease the environmental pollution and also conserve our natural resources.

III. MATERIALS USED

The strength of the concrete is mainly depend upon the properties of the ingredients are to be used in the concrete. Following are the ingredients used in the experimental work.
Ingredient Materials used in the Concrete:

- OPC 43 Cement.
- River Sand as fine aggregate.
- Quarried and crushed stone as coarse aggregate.
- Red mud(RM)
- Used Foundry sand(UFS)

A. Cement

In this experimental work, Ordinary Portland Cement (OPC) 43 grade conforming to IS: 8112 – 1989 was used. The cement used was from the local distributors. The cements were tested according to IS standard conforming to (8112-1989) to determine its various physical properties.

B. Fine Aggregate (Sand)

Locally available river sand belonging to zone II and passing through 4.75mm sieve of IS 383-1970 was used for the project work.

C.Red Mud

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

collected red mud from Hindalco Industries Limited, Belgaum, and Karnataka (INDIA).

Table 3: Comparison of Red mud & Cement

Sl No	Material Property	Red mud	Cement
1	Specific Gravity	**2.90**	**3.10**
2	Fineness (%)	**4.10**	**4**

D. Used Foundry Sand

Foundry sand is a by-product of the castings industry typically comprising uniformly sized sands with various additives and metals associated with the specific casting process. Most metal casting sand (FS) is high quality silica sand with uniform physical characteristics. We collected Used Foundry sand from local distributors of Harihara (Karnataka).

Table 4: Comparison of Used Foundry Sand & fine aggregate

Sl No	Material Property	Fine aggregate	Used Foundry Sand
1	Specific Gravity	**2.58**	**2.68**
2	Fineness Modulus	**2.96**	**3.19**

E. Water

Water fit for drinking is generally considered fit for making concrete. Water should be free from acids, oils, alkalies, vegetables or other organic Impurities. Soft waters also produce weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form a cement paste in which the inert aggregates are held in suspension until the cement paste has hardened.

IV EXPERIMENTAL METHODOLOGY

The methodology adopted has been divided into two phases. The 1st phase covers the possibility of replacing part of cement with Red mud in cement mortar. The 2nd phase covers the study of fresh and hardened properties of concrete incorporated both Red mud & used Foundry sand waste (Replacement to Fine Aggregate). The investigation work includes the following parts:

Part I: Investigating the effect of strength parameters by replacing a part of the cement with red mud in cement mortar.

Part II: To study the effect of Red mud replacement to cement & Used Foundry sand replacement to Fine Aggregate on strength parameters of concrete.

Part I: Investigating the effect of replacing a part of the cement binder with red mud in Mortar.

The mix proportion of the mortar was 1.0 (Portland cement): 3.0 (fine aggregate) and the water/cement ratio was 0.45. After mixing, a vibrating table was used to ensure efficient compaction. Mortars containing distinct additions of red mud (5, 10, 15, 20, 25 and 30% in weight) were prepared and tested as per Indian codal provisions.

Part II: To Study the effect of Red mud & Used Foundry sand (Replacement to Fine Aggregate) on strength parameters of concrete.

After getting the optimum mortar strength from the above part I, the next procedure is to design M30 grade mix by using as per IS 10262:2009 codal provisions keeping the red mud percentage as constant (optimum obtained) and vary the Used Foundry sand as 10%.20%,30%,40%,50% and 60%(replacement to fine aggregates). Further development mixes are studied for both fresh as well as hardened properties.

V. EXPERIMENTAL RESULTS AND DISCUSSION

5.1 Workability Test Results

Following table 5 gives the workability test results of concrete produced by using Red Mud (RM) and Used Foundry sand (UFS).Variations of slump cone is depicted as shown in fig 1.

Table 5: Workability tests results

Replacement of cement by Red mud and Fine aggregate by Used Foundry sand (%)	Fresh properties tested	
	Slump (mm)	Compaction factor
0% RM + 0% UFS	67	0.82
20% RM + 10% UFS	69	0.84
20% RM + 20% UFS	71	0.86
20% RM + 30% UFS	74	0.88
20% RM + 40% UFS	76	0.89
20% RM + 50% UFS	73	0.84
20% RM + 60% UFS	70	0.80

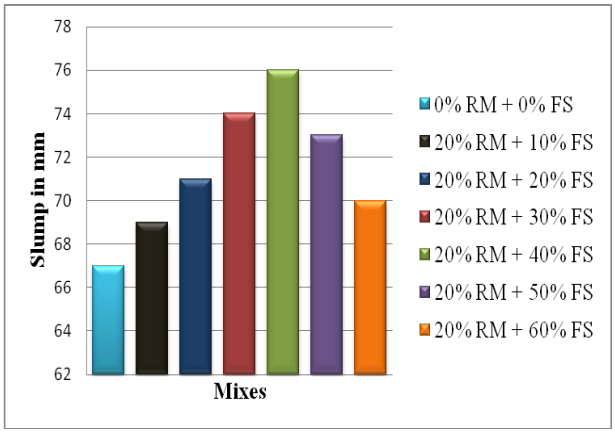


Fig. 1: Variation of Slump

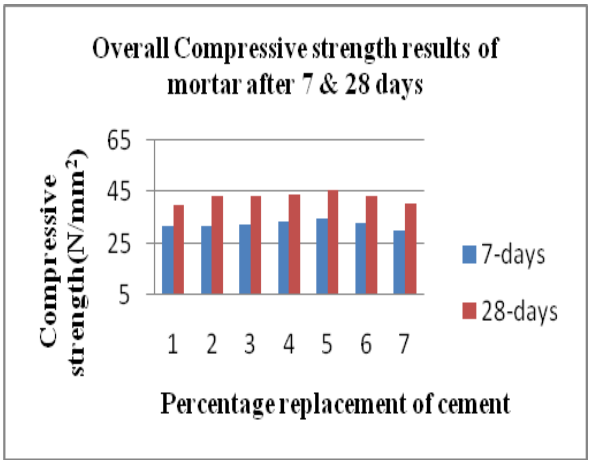


Fig. 2: Variation of overall compressive strength of mortar

Observation for slump cone test

The figure 1 indicates the variations of slump value. From the graph it can be observed that the slump is gradually increasing with increase of copper slag content and the maximum slump is obtained for 20% RM + 40% FS.

5.2 Compressive strength of the mortar

Compressive strength of the mortar design mix was check by casting and testing of cubes (size 77 mm x 77 mm x77 mm) after the curing period of 3 days, 7 days & 28days. Following table 6 gives the overall results of compressive strength of mortar produced by using Red mud. Also it gives the percentage increase or decrease of compressive strength with respect to control mix (0%).

Table 6: Compressive Strength results of Mortar for 7-Days and 28-Days

SL. NO	Replacement of cement by Red mud (%)	7-days Compressive strength of Mortar (N/mm^2)	28-days Compressive strength of mortar (N/mm^2)
1	0	31.50	40.03
2	5	31.71	43.20
3	10	32.37	43.28
4	15	33.12	44.03
5	**20**	**34.62**	**45.63**
6	25	32.66	43.17
7	30	29.85	40.40

Observation Compressive strength of mortar

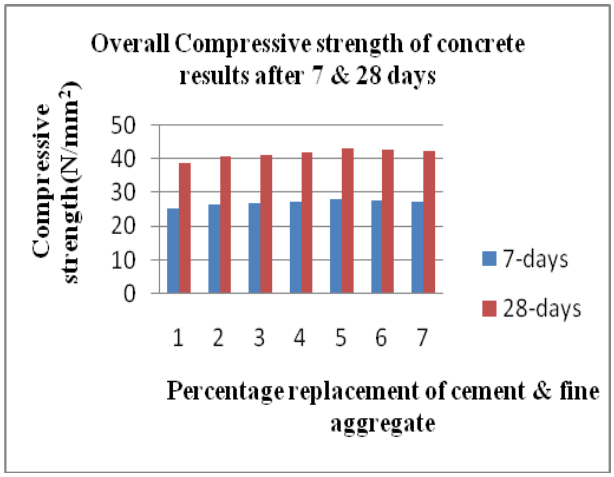
The above fig 2 indicates the compressive strength of mortar at 7days and 28days simultaneously. In that graph the compressive strength increases gradually, when increases the percentage of Red mud. Finally get the maximum strength at 20% replacement of cement by Red mud. After optimum the graph gradually decreases and the lowest strength is at 30% replacement of cement by Red mud.

5.3 Compressive Strength Test Results of Concrete

Following table 7 gives the overall results of compressive strength of concrete produced by using Red mud (RM) and used foundry sand (UFS).

Table 7: Compressive Strength results of concrete for 7-Days and 28-Days

SL. NO	Replacement of cement by Red mud and Fine aggregate by Used foundry sand (%)	7-days Compressive strength of concrete (N/mm^2)	28-days Compressive strength of concrete (N/mm^2)
1	0% RM + 0% UFS	25.29	38.90
2	20% RM + 10% UFS	26.45	40.69
3	20% RM + 20% UFS	26.91	41.39
4	20% RM + 30% UFS	27.38	42.13
5	**20% RM + 40% UFS**	**28.17**	**43.34**
6	20% RM + 50% UFS	27.78	42.74
7	20% RM + 60% UFS	27.55	42.38



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5	**20% RM + 40% UFS**	**28.17**	**43.34**
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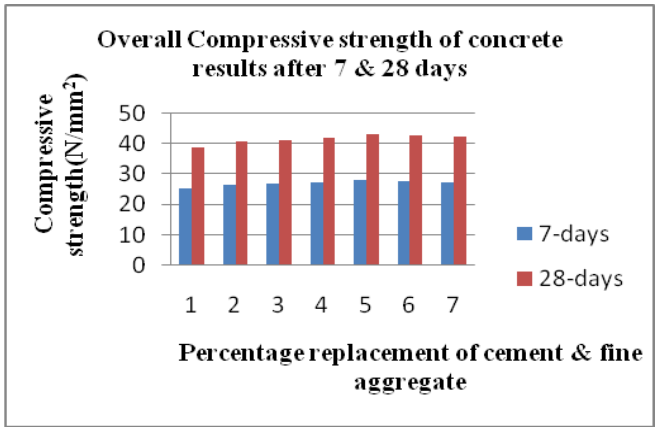

Fig. 3: Variation of overall compressive strength of concrete

Observation for Compressive strength

The above fig 3 indicates the compressive strength of concrete at 7-days and 28- days simultaneously. In that graph the compressive strength increases gradually and getting maximum compressive strength at 20% Red Mud + 40% used foundry sand after that the compressive strength is gradually decreasing both in 7-days as well as in 28- days curing periods. Finally it can be concluded that the optimum usage of Red mud and Used foundry sand found to be 20% Red Mud + 40% Used foundry sand.

5.4 Split Tensile Strength Test Results of Concrete

Following table 8 gives the overall results of split tensile strength of concrete produced by using Red mud (RM) and used foundry sand (UFS).

Table 8: Split tensile Strength results of concrete for 7-Days and 28-Days

Sl. No	Replacement of cement by Red mud and Fine aggregate by Used foundry sand (%)	7-days split tensile strength of concrete (N/mm^2)	28-days split tensile strength of concrete (N/mm^2)
1	0% RM + 0% UFS	2.53	3.89
2	20% RM + 10% UFS	2.64	4.07
3	20% RM + 20% UFS	2.69	4.14
4	20% RM + 30% UFS	2.74	4.21
5	20% RM + 40% UFS	2.82	4.33
6	20% RM + 50% UFS	2.78	4.27
7	20% RM + 60% UFS	2.75	4.24

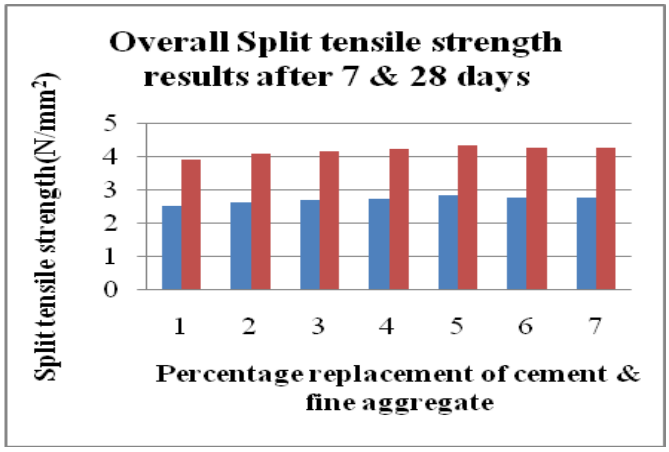

Fig. 4: Variation of overall split tensile strength

Observation for Split tensile strength

The above fig 4 indicates the split tensile strength of concrete at 7-days and 28- days simultaneously. In that graph the split tensile strength increases gradually and getting maximum split tensile strength at 20% Red Mud + 40% Used foundry sand after that the split tensile strength is gradually decreasing both in 7-days as well as in 28- days curing periods. Finally it can be concluded that the optimum usage of Red mud and Used foundry sand found to be 20% Red Mud + 40% Used foundry sand.

VI. CONCLUSIONS

From this experimental study following points can be drawn

- After testing cement mortar samples (0% to 30% replacement of Cement by Red Mud) with an increment of 5 %, it can be said that the optimum use of red mud is 20% as a partial replacement of cement by Red Mud.
- The specimen with Red mud and Used Foundry Sand as replacement to cement and fine aggregate respectively was found to be good in compression which has compressive strength for 7days 10.22% & 28 days 10.24% more than that of conventional concrete after 28-days curing period for 20% Red Mud + 40% Used Foundry Sand.
- Better split tensile strength was achieved with the replacement of Red mud and Used Foundry sand in concrete. The strength has increased up to 7days 10.28% & 28 days 10.16% when compared to that of the conventional concrete specimen after 28-days curing period for 20% Red Mud + 40% Used Foundry Sand.
- Considering all the above points it is interesting to say that the optimum utilization of Red Mud in cement mortar was found to be 20 % as a partial replacement of cement by Red Mud and Used Foundry Sand is 40% in concrete as replacement to fine aggregate to obtain a considerable design mix.

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