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Experimental Study on Utilization of Red Mud and Quarry Dust in Cement Mortar and 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. 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% Quarry dust and evaluating its compressive and splitting 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 Quarry dust was found to be 20% Red mud + 40% Quarry dust(for concrete).**

Keywords: **Red mud, Quarry dust.**

I. INTRODUCTION

Industrialization and urbanization are the two worldwide phenomena. Though these are the necessity of the society and are mostly inevitable, one has to look into their negative impacts on the global environment and social life. The major ill effect of these global processes is the production of large quantities of industrial wastes and the problems related with their safe management and disposal. Second problem is the scarcity of land, materials and resources for ongoing developmental activities, including infrastructure.

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. Many of these undesirable industrial rejects contain significant amounts of inorganic ingredients, such as silicon, aluminium, calcium and iron oxides. 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.

1.1 Red Mud:

Red mud is the iron rich residue from the digestion of bauxite. It is one of major solid waste coming from Bayer process of alumina production. In general, about 2-4 tons of bauxite is required for production of each tone of alumina (Al_2O_3) and about one tone red mud is generated. Since the red mud is generated in bulk it has to be stored in large confined and impervious ponds, therefore the bauxite refining is gradually encircled by the storage ponds. At present about 60 million tons of red mud is generated annually worldwide which is not being disposed or recycled satisfactorily.

1.1.1 Effect of re 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.

1.2 Quarry Dust:

Quarry dust is fine rock particles. When boulders are broken into small pieces Quarry dust is formed. It is grey in colour and it is like fine aggregate. The most widely used fine aggregate for making of concrete is the natural sand mined from the riverbeds. However, the availability of river sand for the preparation of concrete is becoming scarce due to the excessive non-scientific methods of mining from the riverbeds, lowering of water table, sinking of bridge piers, etc. are becoming common problems.

Present scenario demands identification of substitute materials for the river sand for making concrete. Quarry dust as a by-product from crushing process during quarrying activities is one of those materials that have recently gained attention to be used as concreting aggregates, especially as fine aggregate. In concrete production it could be used as a partial or full replacement of natural sand. Besides, the utilization of quarry waste, which itself is a waste material, will reduce the cost of concrete production.

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.

- To investigate the utilization of Red mud as supplementary cementitious material and influence of this Red mud on the compressive strength of cement mortar.
- To study the effect of Red mud replacement to cement & Quarry dust replacement to fine aggregate on strength parameters of concrete.
- The development of alternate low-cost and environment suitable building materials from industrial wastes is an economic way.

III. MATERIALS USED

A. Cement:

In this experimental work, Ordinary Portland Cement (OPC) 43 grade conforming to IS: 8112 – 1989 was used.

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, Karnataka (INDIA).

Table 1: Comparison of Red mud & Cement

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

D. Quarry Dust:

Quarry dust is fine rock particles. When boulders are broken into small pieces quarry dust is formed. It is grey in colour and it is like fine aggregate. Quarry dust is collected from local stone crushing units near Davanagere City Karnataka.

Table 2: Comparison of Fine aggregate & Quarry Dust

Sl No	Material Property	Fine aggregate	Quarry Dust
1	Specific Gravity	**2.58**	**2.72**
2	Finess Modulus	**2.96**	**2.68**

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. Secondly, it serves as a vehicle or lubricant in the mixture of fine aggregates and cement.

IV. EXPERIMENTAL PROGRAMING

The experimental work includes the following 2 parts:

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

Part II**:** To study the effect of Red mud (Replacement to cement) & Quarry Dust (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 & Quarry Dust (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 Quarry Dust 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 3 gives the workability test results of concrete produced by using Red Mud (RM) and Quarry Dust (QD).Variations of slump cone is depicted as shown in fig 1.

Table 3: Workability tests results

Replacement of cement by Red mud and Fine aggregate by Quarry dust (%)	Fresh properties tested	
	Slump(mm)	Compaction factor
0% RM + 0% QD	67	0.82
20% RM + 10% QD	70	0.83
20% RM + 20% QD	72	0.84
20% RM + 30% QD	75	0.87
20% RM + 40% QD	78	0.89
20% RM + 50% QD	76	0.80
20% RM + 60% QD	73	0.70

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 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%).

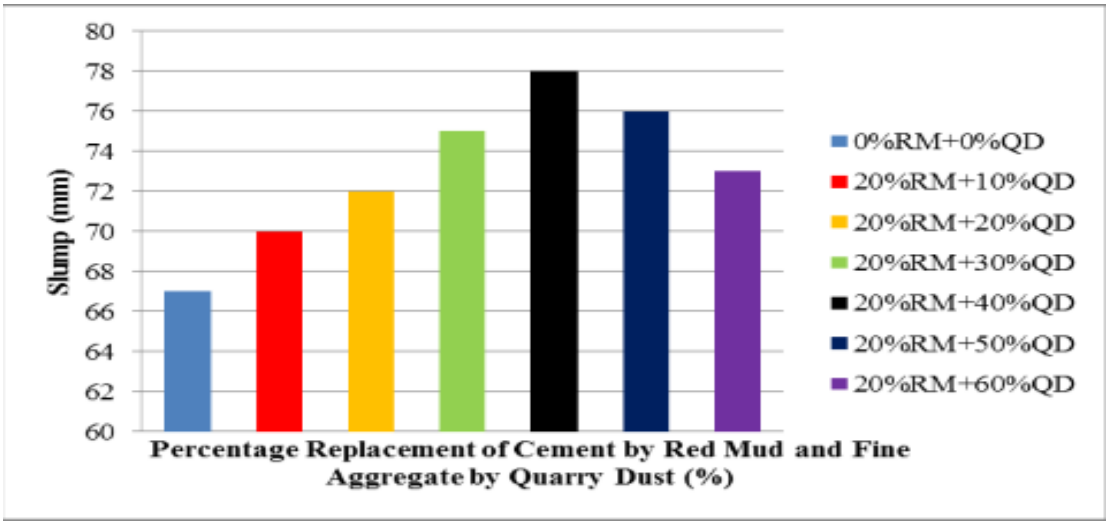

Fig. 1: Variation of Slump

Table 4: Compressive Strength results of Mortar for 7-Days and 28-Days

Replacement of cement by Red mud (%)	7-days Compressive strength of concrete (N/mm^2)	28-days Compressive strength of concrete (N/mm^2)
0	31.50	40.03
5	31.71	43.20
10	32.37	43.28
15	33.12	44.03
20	**34.62**	**45.63**
25	32.66	43.17
30	29.85	40.40

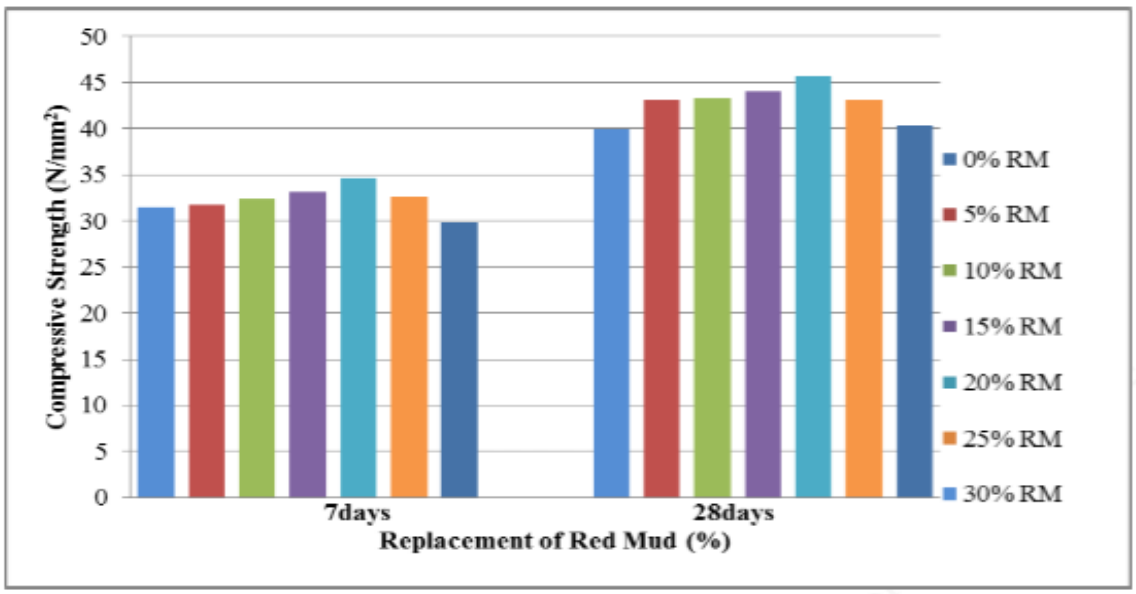

Fig.2: Variation of overall compressive strength of mortar

Observation Compressive strength of mortar:

The above graph indicates the compressive strength of mortar at 7days and 28days simultaneously. In the 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 gives the overall results of compressive strength of concrete produced by using Red mud and Quarry dust.

Table 5: Compressive Strength results of concrete for 7-Days and 28-Days

Replacement of cement by Red mud and Fine aggregate by Quarry dust (%)	7-days Compressive strength of concrete (N/mm^2)	28-days Compressive strength of concrete (N/mm^2)
0% RM + 0% QD	25.14	38.90
20% RM + 10% QD	25.54	39.28
20% RM + 20% QD	26.10	40.19
20% RM + 30% QD	27.52	42.31
20% RM + 40% QD	**29.30**	**45.10**
20% RM + 50% QD	27.92	43.00
20% RM + 60% QD	26.78	41.11

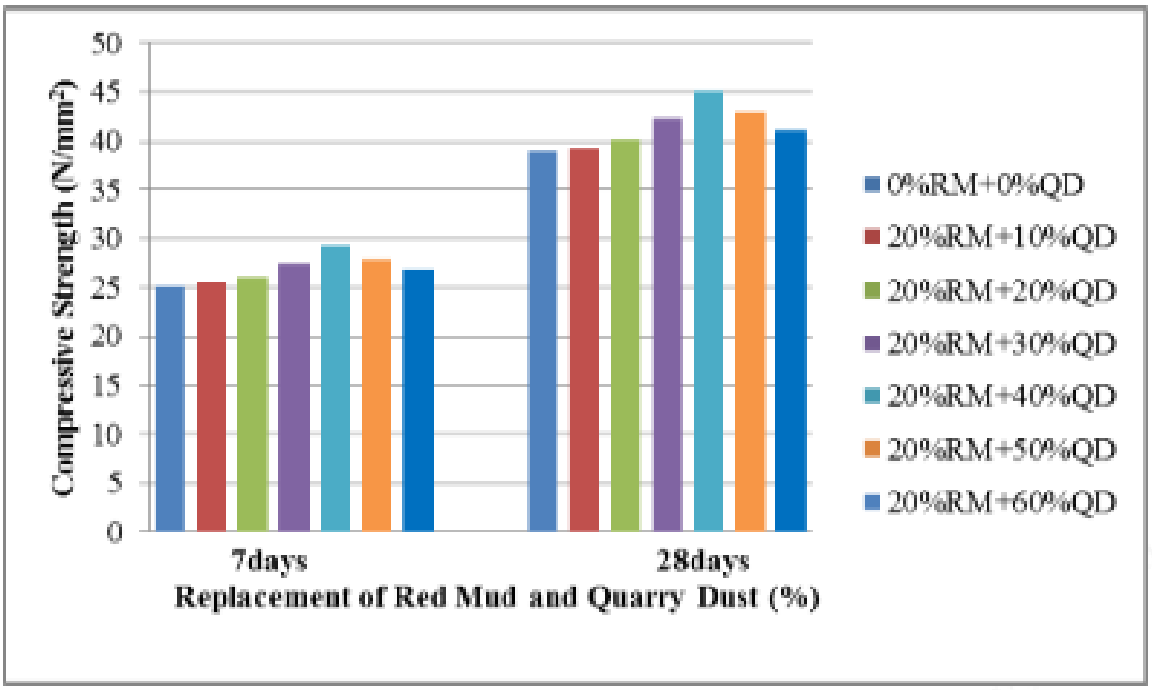

Fig.3: Variation of overall compressive strength of concrete

Observation for Compressive strength:

The above graph indicates the compressive strength of concrete at 7-days and 28- days simultaneously. In the graph the compressive strength increases gradually and getting maximum compressive strength at 20% Red Mud + 40% Quarry Dust 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 Quarry dust found to be 20% Red Mud + 40% Quarry Dust.

5.4 Split Tensile Strength Test Results of Concrete

Following table 5 gives the overall results of split tensile strength of concrete produced by using Red mud and Quarry dust.

Table 5: split tensile Strength results of concrete for 7-Days and 28-Days

Replacement of cement by Red mud and Fine aggregate by Quarry dust (%)	7-days split tensile strength of concrete (N/mm^2)	28-days split tensile strength of concrete (N/mm^2)
0% RM + 0% QD	2.49	3.89
20% RM + 10% QD	2.53	3.93
20% RM + 20% QD	2.60	4.147
20% RM + 30% QD	2.73	4.44
20% RM + 40% QD	2.90	4.51
20% RM + 50% QD	2.77	4.25
20% RM + 60% QD	2.65	4.07

Fig.4: Variation of overall split tensile strength

Observation for Split tensile strength:

The above graph indicates the split tensile strength of concrete at 7-days and 28- days simultaneously. In the graph the split tensile strength increases gradually and getting maximum split tensile strength at 20% Red Mud + 40% Quarry Dust 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 Quarry dust found to be 20% Red Mud + 40% Quarry Dust.

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 as replacement to cement was found to be good in compression which has compressive strength of 9.01% and 12.27% more than that of conventional cement mortar after 7days and 28-days curing period respectively for 20% Red Mud.
- The specimen with Red mud and Quarry dust as replacement to cement and fine aggregate respectively was found to be good in compression which has compressive strength of 14.19% and 13.74% more than that of conventional concrete after 7days and 28-days curing period respectively for 20% Red Mud + 40% Quarry Dust.
- Better split tensile strength was achieved with the replacement of Red mud and Quarry dust in concrete. The strength has increased up to 14.13 and 13.74% when compared to that of the conventional concrete specimen after 7days and 28days curing period respectively for 20% Red Mud + 40% Quarry Dust.
- 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 Quarry dust is 40% in concrete as replacement to fine aggregate to obtain a considerable design mix.

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