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RESEARCH ARTICLE

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EXPERIMENTAL STUDY ON UTILIZATION OF INDUSTRIAL WASTES (RED MUD AND COPPER SLAG) IN MORTAR

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ABSTRACT

The aim of the present work was to investigate the possibility of adding red mud, an alkaline leaching waste that is obtained from bauxite during the Bayer process for alumina production, in the raw meal of Portland cement mortars. The red mud is classified as dangerous and world while generation reached over 117 million tons/year.

Because of storing issues, the waste negatively affects the environment. To solve this problem, an attempt has been made in the present investigation. To study the influence of addition of industrial waste materials like Red mud (RM) & Copper slag (CS) waste, the Portland cement was replaced up to 30 % red mud by the weight of cement And fine aggregates was replaced at constant 10% copper slag waste by the weight of fine aggregates and evaluating its compressive Strength of red mud cement mortar.

Results seem promising for red mud replacement up to 15% by weight of cement and combination of both (RM+CS) shows 10%RM+10%CS replacement to cement and fine aggregates after 3,7and28 days compressive strength.

Keywords: industrial waste, red mud, copper slag waste, mortar, compressive strength

I. INTRODUCTION

Due to industrialization, infrastructure development and soft housing policy of Government of India, the construction industry is in full bloom due to which within short span of time there is a tremendous increase in the utilization of cement and concrete for various construction activities. It is expected that the same rate will continued in the next decade and this may invite the threat to the environment. Availability of raw material required for manufacturing of cement and production of concrete are limited in nature. This increased demand will lead to fast depletion of natural resources and will cause big threat to environment. So as to overcome this problem it is very much essential to utilize the industrial waste materials and by-products generated in manufacturing of cement and in concrete construction.

1.0 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 red mud on environment

In the last decade, the production of aluminum in spite of some stagnancy and set back periods has shown a steady rise of about 1%. The ecological consequences of aluminum production are well known; threatening of surface and underground water and air pollution by waste gases from aluminum electrolysis plant and rolling mills. The degree of damage inflicted to ground water and air during the single production stages from bauxite to aluminum depends on a couple of tact of which those connected with the alumina winning and red mud disposal.

1.1.2 Utilization of red mud

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, glass production and production of road base. And they have made some progress, especially in the production of cement using red mud.

Production of Construction Materials from Red Mud

- Cement
- Brick
- Glass
- Aerated Concrete Block
- Road base Material

1.2 Copper slag

Copper Slag is a byproduct material produced from the process of manufacturing copper. It is totally inert material and its physical properties are similar to natural sand. The slag is a mixture of lime, silica and alumina, the same proportion. For every tone of metal production, about 2.2 ton of waste slag is generated. Dumping or disposal of such huge quantities of slag cause environmental and space problems. During the past two decades, attempts have been made by several investigators and copper producing units all over the world to explore the possible utilization of copper slag. The Physical and mechanical properties of granulated copper slag shows that it can be used to make products like coarse and fine aggregates, cement, fill, ballast, roofing granules, glass, tiles etc.

1.2.1 Uses of copper slag

- Copper slag has also gained popularity in the building industry for use as a fill material.
- Contractors may also use copper slag in place of sand during concrete construction.
- Copper slag can also be used as a building material, formed into blocks.
- Copper slag is widely used in the sand blasting industry and it has been used in the manufacture of abrasive tools.
- Copper slag is widely used as an abrasive media to remove rust, old coating and other impurities in dry abrasive blasting due to its high hardness (6-7 Mohs), high density (2.8-3.8 g/cm^3) and low free silica content.

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.Following are the objectives derived by exhaustive study of literature:

- To Investigate the Utilization of Red mud as Supplementary Cementitious Material (SCM) and influence of this Red mud on the Strength Parameters of mortar.
- To Study the Effect of Red mud & Copper Slag (Replacement to Fine Aggregate) on Compressive strength of mortar.

III. MATERIALS

A. Cement

In this experimental work, Ordinary Portland Cement (OPC) 43 grade conforming to IS: 8112 - 1989was used. The cementused was Ultra tech cement from the local distributors. The physical properties of the cement were determined as per IS: 4031-1968 and are presented in table I.

Table I: Properties of Ultra tech cement (OPC 43)

S.No	Material Property	Results Obtained	Requirement as per IS:8112-1989
1	Specific gravity	3.10	3.15
2	Finess modulus	5.10%	Not more than 10%
3	Standard consistency	33%	Not more than 35%
4	Initial setting time	55Min	Not less than 30 minutes
5	Final setting time	355Min	Not more than 600 minutes
6	Compressive strength 3-Days(Mpa)	20.50	23
	7-Days(Mpa)	31.50	33
	28-Days(Mpa)	43.20	43

B. Sand (Fine Aggregate)

Locally available river sand belonging to zone II and passing through 4.75mm sieve of IS 383-1970 was used for the project work. The physical properties of the fine aggregates are presented in below table II.

Table II: Properties of Fine Aggregate (Sand)

Sl. No.	Properties	Results obtained
1	Specific Gravity	**2.58**
2	Fineness Modulus	**3.35%**
3	Water Absorption (24 hours)	**1%**

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 III: Properties of Red mud

Sl. No.	Material Property	Results Obtained
1	Specific gravity	**2.90**
2	Fineness	**4.10%**

D.Copper Slag

Copper slag is one of the materials that is considered as a waste which could have a promising future in construction Industry as partial or full substitute of either cement or aggregates. We collected Copper slag from local distributors of Coimbatore (Tamilnadu).

Table IV: Properties of Copper Slag

Sl. No.	Properties	Results obtained
1	Specific Gravity	3.58
2	Fineness Modulus	3.19%

IV. METHODOLOGY DETAILS

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 & Copper Slag (Replacement to Fine Aggregate) on compressive strength of mortar.

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 codal Indian codal provisions.

Part II: To Study the effect of Red mud & Copper Slag (Replacement to Fine Aggregate) on compressive strength of Mortar.

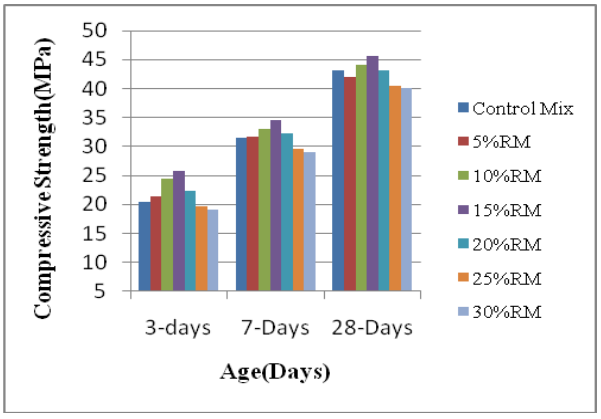
In the second part of our investigation, fix the Copper Slag waste as constant (10%) replacement to fine aggregate and vary the Red Mud (5, 10, 15, 20,25 and 30%) replacement to cement, for the mix proportion 1:3 and water content equal to [(P/4+3.0) % of combined weight of cement and sand]. Here, P is the normal consistency of cement paste. The cubes are cast and cured as per Indian standard codal provision and tested for compressive strength in the compression testing machine at different ages: 3, 7 and 28 days.

V. RESULT ANALYSIS OF COMPRESSIVE STRENGTH TESTING

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. The obtained results are tabulated below

Table V: Compressive strength results (Red Mud)

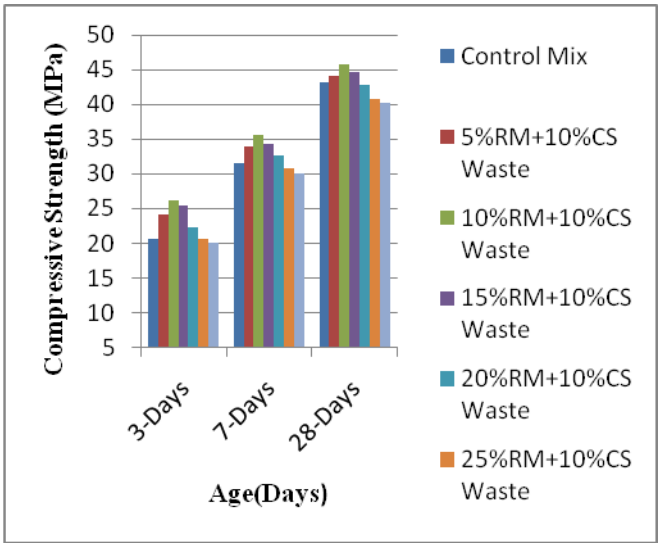
%replacement of cement by Red Mud	3-Days Mpa	7-Days Mpa	28-Days Mpa
Control Mix	20.53	31.51	43.20
5%RM	21.40	31.70	42.10
10%RM	24.50	33.10	44.00
15%RM	25.70	34.60	45.60
20%RM	22.30	32.40	43.20
25%RM	19.80	29.70	40.40
30%RM	19.10	29.00	40.03



Graph I: Compressive strength at 3days, 7days and 28days

Table VI: Compressive strength results (Red Mud + Copper Slag Waste)

%Replacement of cement by Red Mud& sand by Copper Slag waste	3-Days Mpa	7-Days Mpa	28-Days Mpa
Control Mix	20.53	31.51	43.20
5%RM+10%CS	21.40	31.70	42.10
10%RM+10%CS	24.50	33.10	44.00
15%RM+10%CS	25.70	34.60	45.60
20%RM+10%CS	22.30	32.40	43.20
25%RM+10%CS	19.80	29.70	40.40
30%RM+10%CS	19.10	29.00	40.03



Graph II: Compressive strength at 3days, 7days and 28days

VI. DISCUSSIONS

A.Effect of Replacement of Cement by RM on Compressive strength of mortar

Blended cement samples, six in number are prepared with replacement of cement by RM with increment of 5 percent (i.e. 5%, 10%, 15%, 20%, 25%&30%).

From the graph it can be observed that, there was an initial decrease in the compressive strength for 5 % replacement of cement by RM.But from the next replacements i.e. 10 % and 15 % the compressive strength are increased with the increase in the % replacement of cement by RM. Then after, for 20 %, 25 %& 30% replacement of cement by RM there was a decrease in the compressive strength as the % replacement of cement by RM increased.

Hence by observing graphI of mortar design mix, it can be said that the 15 % replacement of cement by RM gives the maximum compressive strength as compare with the control mix after 3 days, 7 days & 28 days curing period.

A.Effect of Replacement of Cement by RM and fine aggregate by CS Waste on Compressive strength of mortar

The above graph II indicates the compressive strength of mortar mixes with various replacements of cement by red mud & fine aggregate by copper slag waste (constant 10%). The optimum strength gained after 3, 7 and 28 days

curing period is at 10%RM+10% CS Waste replacements to cement and fine aggregate.

VII. CONCLUSION

From this experimental study following points can be drawn:

- After testing cement mortar samples (5% to 30% replacement of Cement by Red Mud) with an increment of 5 %, it can be said that the optimum use of red mud (RM) is 15% as a partial replacement of cement by RM.
- The specimen with RM and CS Waste was found to be good in compression which had the compressive strength of 45.75Mpa, more than the control mix, and it is influenced by addition of copper slag waste (CS waste).

Considering all the above points it is interesting to say that the optimum utilization of Red Mud in mortar is 15 % as a partial replacement of cement by RM.

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