

Experimental Study on the Effect of Cement and Sand Replacement with Red Mud and Quarry Dust in Cement Concrete Pavements

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Abstract: The main objective of the project is experimental study of the possibility of utilizing the waste red mud (bauxite residue) and quarry dust in cement concrete. Red mud is a by-product produced in the process of extraction of aluminium from bauxite. The red mud generated by this process is highly alkaline with a pH usually ranging from 10 to 12. It leads to serious environmental problems. Worldwide there are approximately 80 to 90 million tons of red mud is being generated every year. The production of 1 ton aluminium generates 1-2 tonnes of red mud. The storage of red mud is economically and environmentally problematic due to the risk of contamination of natural resources and living organisms. Red mud can be used in replacement of cement in concrete. The quarry dust which is available from local resources can be used as a replacement of river sand in a conventional concrete pavements. This study aims at describing such utilization and their effective usage in concrete. Experiments have been conducted under laboratory conditions to assess the compressive strength and flexural strength of the concrete cubes made of red mud and quarry dust. By conducting the model tests we can replace the 15% of cement with red mud and 30% of sand with quarry dust.

Keywords: red mud, quarry dust, compressive strength, flexural strength.

Introduction

The global production of bauxite in 2015 is 285 million tones approximately and the main producing countries are china, Australia, India, Brazil, Guinea. Ranking best in the worldwide production, India produced 15.5 million tons of bauxite [1] in 2015. Indian bauxite are grouped into 5 major geological & geographical areas. They are as Eastern ghats, central India, west coast, Gujarat, Jammu & Kashmir.

The Indian aluminium sector is characterised by large integrated players like Hindal co., national aluminium company (NALCO), Indian aluminium company (INDAL) bharat aluminum (BALCO) and madras aluminum (MALCO). Bayer process production of aluminum: Alumina refining comprises the conversion of bauxite to aluminium oxide (Al₂O₃) (alumina) using the Bayer process. In the production of alumina process waste is generated is a red mud. Roughly 0.5-1.0 tons of red mud waste are generated per 1 ton of aluminium produced. The storage of large quantities of bauxite residue (red mud) is ex-pensive and high p^Hrate (10-12) and requiring large of disposal areas and causing serious environmental problems are issued.

In recent year's present replacing clinker by pozzolanic materials and using new alternative binder's produced by industrial solid wastes have become a prime interest in cement industry. With attempts to lower CO₂ emissions and decrease the production cost of cement, have been red mud used as a pozzolanic pigment for colored concrete.

The successful utilization of various industrial by products such as (fly ash, silica fume, rice husk ash, foundry waste lime stone powder, red mud) in cement concrete. in addition to this an alternative source for the potential replacement of natural aggregates in cement concrete has gained good attention.

As a result reasonable studies have been conducted to find the suitability of quarry dust in cement concrete to overcome the stress and demand for river sand and cement in construction of roads and other works.

Chemical composition of cement and red mud nearly equal hence we can replace of cement by red mud and quarry dust is replaced by sand in improved hardened concrete properties.

Table 5.1 Chemical composition of cement and red mud

Chemical composition	Cement	Red mud
CaO	63.6	35.3
SiO ₂	19.49	18
Al ₂ O ₃	4.54	6.31
Fe ₂ O ₃	3.38	12.38
Na ₂ O	0.13	2.71
MgO	2.36	1.13
K ₂ O	0.58	0.45

This study describes about such utilization and their effective usage in concrete. Experiment have been conducted under laboratory condition to assess the compressive strength and flexural strength. The red mud and quarry dust has being replaced on cement and fine aggregate. For various proportions of red mud such as 0%, 5%, 10%, 15%, 20% and 25% and fine aggregate 0%, 10%, 15%, 20%, 25%, 30%, 35% and 40% to the weight of cement and fine aggregate. This paper point's out another promising direction for the proper utilization of red mud and quarry dust.

OBJECTIVE OF STUDY

The specific objectives of this study:

1. To study the strength properties of hardened concrete for replace cement by red mud for different percentage of replacement.
2. To study the optimum strength of the red mud concrete + strength properties of hardened concrete for replaced river sand by quarry dust for different percentage of replacement.
3. To find out optimum percentage of replaced cement and sand by red mud and quarry dust.

LITERATURE REVIEW

1. Sucharitha patal, B.K.pal (1): Current status on industrial waste red mud on overview have made investigated on the amount of the red mud generated per ton of the alumina processed, various greatly with the type of the bauxite ore used. Due to this hazardous nature it is a great challenge to researcher to develop new methods for the application of red mud. Various research work going on for storage, disposal and utilization of the red mud in all over the world. Were studied this reviews the current status and future trend of the red mud characterization, disposal, various neutralization methods and utilization in world as well as in Indian context.

2.M.P.Suresh Kumar, S.K. Gowtham: were studied the potential utilization of industrial waste (red mud) in concrete. Have made investigation on partial replacement of cement with red mud for studying mechanical properties of concrete. The percentage of red mud partial replacement of concrete are, 0%, 5%, 10%, 15%, and 20% for M₂₀ grade concrete. From the experimental studies 10% partial replacement of cement with red mud improved hardened concrete properties.

3. P. Ashok, M.P. Suresh Kumar: experimental studies on current utilizing red mud and hydrated lime as a partial replacement of cement M₃₀ grade. The percentage of red mud partial replacement of cement are, 0%, 5%, 10%, 15%, 20%, and 25% and 5% hydrated lime partial replacement of cement. From the experimental studies 15% partial replacement of cement with red mud and 5% hydrated lime improved cement concrete properties.

4.Venkata Sairam Kumar NB Pandurangarao Krishna sai M L N et al: have made investigation on partial replacement of sand with quarry dust for studying mechanical properties of concrete. The percentages of quarry dust partial replacement of sand in concrete are, 0%, 10, 15%, 20%, 25%, 30%, 35%, and 40% for M₂₀, M₃₀ grade concrete. From experimental studies 25% of partial replacement of sand with quarry dust improved hardened concrete properties.

5. Ramarao Chimata, Venkateswara Rao.J.:have made investigated on partial replacement of sand with quarry dust and glass fibers for studying mechanical properties of rigid pavements. The percentage of quarry partial replacement of sand in concrete are, 0%, 10%, 15%, 20%, 30% and 40% and 0.2% glass fibers for M₄₀ grade concrete. For experimental studies 30% of partial replacement of sand with quarry dust & glass fibers improved hardened concrete properties.

MATERIALS AND METHODOLOGY

1. Materials: Ordinary Portland cement (opc) of grade 43 with a specific gravity 3.13 red mud waste is taken from aluminium refineries of a red mud storage ponds and quarry dust is taken from locally available sources, aggregates with a maximum size of 20mm down size, sand were used as coarse aggregate and fine aggregates respectively. Specific gravity of

coarse and fine aggregates were found to be 2.82 and 2.74 respectively.

2.Physical properties of aggregate:

Table 5.2 Physical properties of aggregates

Material Property	Percentage
Water absorption	0.5%
Aggregate Impact value	24.6%
Aggregate Crushing value	26.11%
Flakiness Index	8%
Elongation Index	11%

3. Mix Design: Samples are prepared M-40 grade. For the design mix IS: 10262-2009 recommendations are adopted. Mix proportions of M-40 are given in the following table

Table 5.3 Mix design

Material	Weight
Cement	428.6kg/m ³
Sand	556.3kg/m ³
Coarse aggregate	1156kg/m ³
W/C ratio	0.38

4. Specimens preparations:In a mixer red mud and quarry dust and cement are mixed thoroughly in required proportions until uniform color was achieved. Next, sand and coarse aggregates are added and mixed thoroughly again for 3 to 4 minutes. The mix was then transferred to cubes (150mmx150mmx150mm) and prisms (100mmx100mmx100mm). During transferring the mix was compacted in three or four layers. Mix was compacted on vibrator to expel the air.

5. Test Setup: The specimen were tested for 7 and 28 days compressive strength. The specimens were subjected to a compressive force at the rate of 5 KN/sec until they failure occurs. The mean value of compressive strengths of threetest cubes in a series is reported as compressive strength of a particular mix. For finding the flexural strength of prisms IS: 516-1959 guide lines are followed.

RESULTS AND DISCUSSIONS

1. Workability of Concrete: Slump cone test was performed to determine the workability of the concrete mix. The slump values for different mixes as follow:

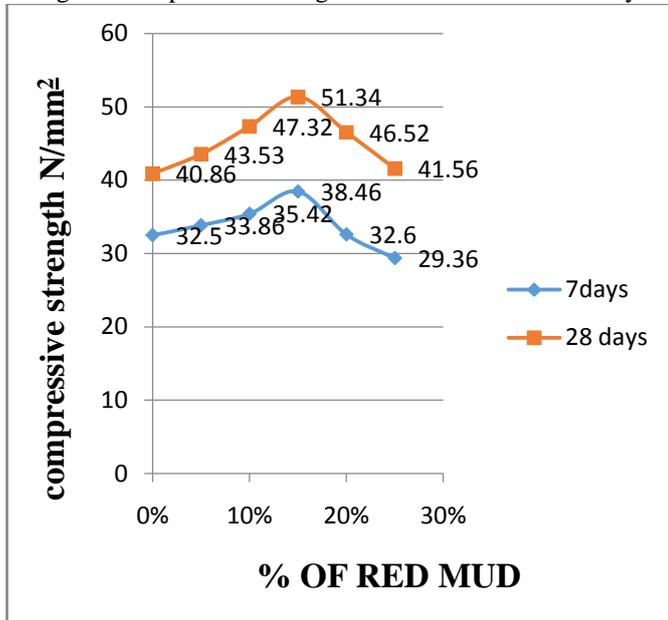
Table 5.4 Workability of concrete

Mix Type	Slump(mm)
Conventional concrete (cc)	53
Red mud concrete	41
Quarry dust concrete	37

From above results we observe that workability is reduced red mud and quarry dust concrete compared to conventional concrete.

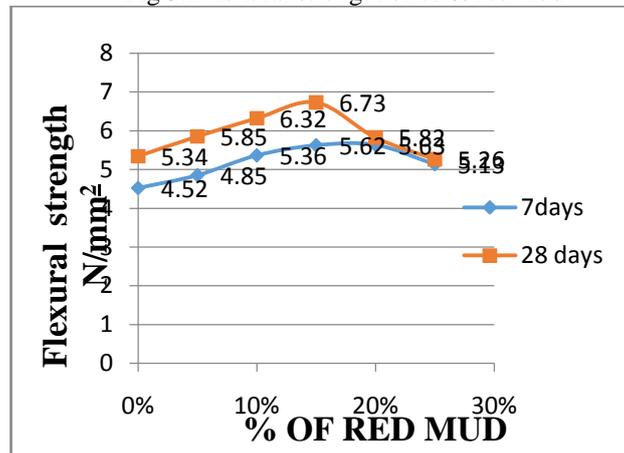
2. Compressive strength test: Compressive strength values of the cube specimens were at 7&28 days testing given in bellow graph. From figure it was observed that rate of increment in compressive strength of the red mud concrete is 18.33% and 25.4% at age of 7&28 days respectively compared to conventional concrete.

Fig 3.1 Compressive strength of cc & red mud 7&28days.



3. Flexural strength test: Flexural strength of beam specimens are tested on UTM at 7&28 day. Results are given bellow:

Fig 3.2 flexural strength of cc & red mud

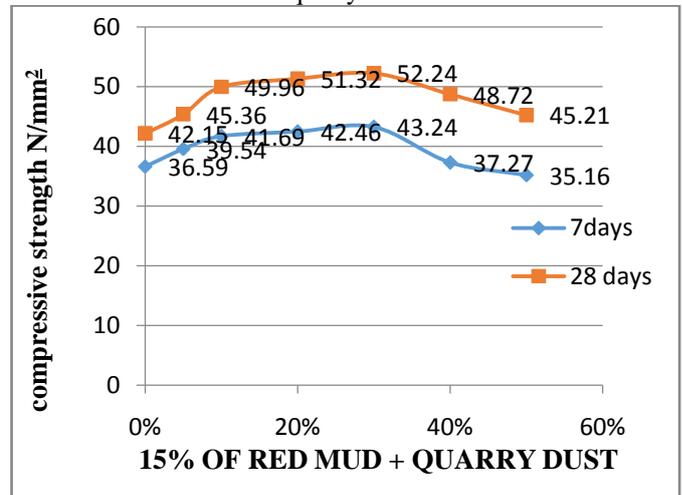


Was observed that rate of increment in flexural strength of the red mud concrete is 24.33% and 26.02 at age of 7&28 days respectively compared to conventional concrete. From the graph it was clear that there was an improvement in flexural strength of the red mud.

4. Compressive strength test:Compressive strength of cube specimens were at 7&28 days testing in bellow graph. From figure 3.3it was observed that rate of increment in compressive strength 15%redmud and quarry dust concrete is 18.17% and 23.93%at age of 7&28 days respectively compared to

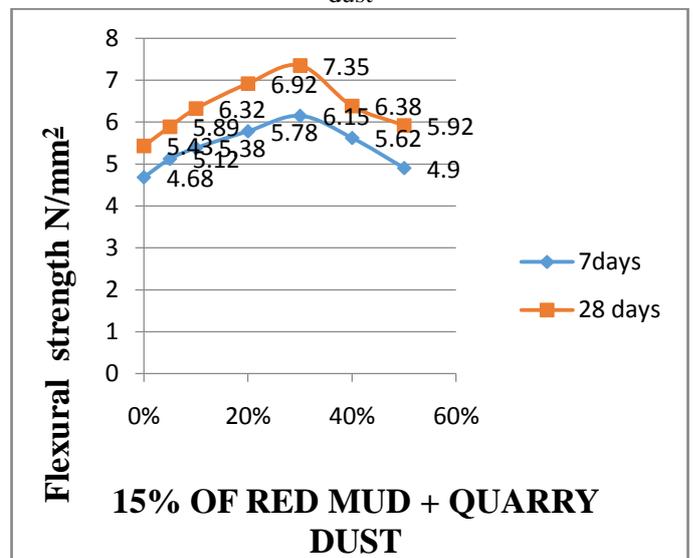
conventional concrete. From the graph it was clear that there is an improvement in compressive strength of red mud and quarry dust.

Fig 3.3 Compressive strength of 15% red mud concrete & quarry dust



5. Flexural strength test:Flexural strength of the beam specimens are tested on UTM at 7&28 days. Results are given bellow:

Fig 3.4 Flexural strength of 15% red mud concrete & quarry dust



it was observed that rate of the red mud and quarry dust concrete is 31.41% and 35.54 at age of 7&28 days respectively compared to conventional concrete. From graph it was clear that there was an improvement in flexural strength of red mud and quarry dust.

CONCLUSIONS

From the test results 15% replacement of cement with red mud in concrete improves concrete mechanical properties compared to conventional concrete. Hence it is optimum replacement of cement by red mud.

By replacing sand with quarry dust and adding optimum content of 15% red mud replacing the cement we can improve concrete mechanical properties compared to conventional concrete. Hence optimum replacement 15% red mud and replacement of sand by quarry dust. The optimum dosage of replacement of sand by quarry dust was 30%.

It is evident that from the results of compressive strength and flexural strength of red mud and quarry dust increases to 35.5% at age of 28 days compared to conventional concrete. By using the industrial waste as partial replacement of cement and sand we can reduce the construction cost.

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FIGURES:

Compressive strength testing on cube specimens



Flexural strength of the beam specimens are tested on UTM.

