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Comparison on Compressive Strength of Conventional Concrete With Red Mud Concrete

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Abstract – *Red mud generated out of Bayer's process for alumina production from Bauxite is a high volume solid waste. Red mud does not affect the cement properties and improves the cement quality. The aim of this paper is to investigate the possibility of partially replacing cement with red mud and also to find the compressive strength. From the test result the compressive strength of red mud is found to be greater than conventional concrete up to 10%. But beyond 10% the value starts decreasing. Use of this waste material in concrete is cost effective and environment friendly way to disposal of waste.*

Key Words: Red mud, Bayer's process, Alumina, Bauxite, Compressive strength

1. INTRODUCTION

Concrete is the primary construction material used around the world. It is most widely used in all types of civil engineering works and it is a manmade product, essentially consisting of cement, aggregate, water and admixtures. Most concretes used are lime based concretes such as Portland cement concrete or concretes made with other hydraulic cements, such as calcium aluminate cements. To produce concrete from most cement, water is mixed with the dry powder and aggregate, which produces a semi-liquid slurry that can be shaped, typically by pouring it into a form. Properties of concrete are influenced by many factors mainly due to mix proportion of cement, sand, aggregates and water. Ratio of these materials controls the various concrete properties such as: Grades (M20, M25, M30 etc.), compressive strength, characteristics strength, tensile strength, durability, creep, shrinkage, unit weight, modular ratio, poisson's ratio.

Concrete in spite of being the most popular and most economical construction material it has major shortcomings in terms of embedded energy and is also one of the major causes of greenhouse gas effect. However, the production of cement leads to the dissipation of significant amount of carbon dioxide and greenhouse gas emission. One ton of Portland cement clinker production creates one ton of carbon dioxide and other greenhouse gases. To reduce the emission of carbon dioxide concerning the production of cement, we must reduce the usage of cement, and therefore the demand of Portland cement. If the cement is partially replaced with the material having desirable properties, then the natural material can be saved and can reduce the emission of carbon dioxide into the atmosphere. Industrial waste dumping to the nearest site which spoils the land and atmosphere as well as it also affects aesthetics of urban environment.

1.1 Red Mud

Red mud is the iron rich residue from the digestion of bauxite. It is one of the major solid waste coming from Bayer process of alumina production. In general, about 2-4 tones of bauxite is required for production of each ton of alumina and about one ton 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. In the most common method of dumping that is the impoundment on land in a diked impervious area called ponds. The mud slurry is pumped to the ponds situated close to the bauxite refinery. The mud accumulates and settles in the pond in due course of time. In order to reduce alkali pollution through red mud a number of methods using drainage decantation and special technique such as dry disposal have been developed. However the dry disposal can only conserve the land to a considerable extent, but the conservation of minerals remains unattempted.

Fig-1: Red Mud

2. PREVIOUS RESEARCH

D Linora Metilda et.al (2015) conducted investigations on optimum possibility of replacing cement partially by red mud in concrete. The materials used for the experiment was cement, red mud, crushed rock of maximum 20mm size and potable water. The test was conducted on M30 grade concrete with a mix ratio of 1:1.462:2.695 and 0.44 water-cement ratio. The red mud was used for replacing of cement by 5% intervals in weight up to 25%. The test conducted was compressive strength, split tensile strength and flexural strength test. After 7 days, 14 days and 28 days of curing, it was observed that the maximum compressive strength was obtained at 15% replacement of cement by red mud. The compressive strength reduced beyond 15% replacement of cement by red mud. In case of split tensile strength test, the maximum strength was obtained at 15% replacement of cement by red mud. At 28 days curing, the split tensile strength obtained was greater than conventional concrete strength. The maximum flexural strength was also obtained at 15%. The tensile strength and flexural strength reduced beyond 15% replacement of cement by red mud. Therefore from this study, it was observed that the maximum utilization of red mud in concrete was 15% as a partial replacement of cement.

P Syam Sai, Chandana Sukesh (2016) studied the strength properties of concrete by using red mud as a replacement of cement with hydrated lime. The study was based on the compressive strength, split tensile strength, flexural strength for 7 days and 28 days and also slump cone test. 5%, 10%, 15%, 20% replacement of red mud with 5% hydrated lime was choosen for both M40 and M50 grade concrete. The slump value increased with increase in the percentage of red mud in concrete for 5% of hydrated lime. The optimum value of the compressive strength of red mud concrete for both M40 and M50 grade was 10%. The compressive strength of concrete with 5% hydrated lime was more when compared to the concrete without hydrated lime. The optimum value of split tensile strength by using hydrated lime and without using hydrated lime was at 10% red mud replacement. And also split tensile strength was high for 5% hydrated lime concrete. The optimum value of flexural strength was observed at 0% replacement of red mud concrete for both using hydrated lime and without using hydrated lime at 28 days of curing. The percentage economy was increased with the increase in the grade of concrete but at the same time there was a reduction in the percentage increase of compressive strength.

SowmyaShree T et.al (2016) studied the comparison on durability properties of red mud as partial replacement of cement with hydrated lime for different grades of concrete with and without super plasticiser. The study was carried out with suitable water cement ratio for M20 and M40 grades of concrete. Red mud replacement in 20%, 25%, 30%, 35%, 40% and hydrated lime in 5% was choosen. Slump test, compaction factor test, saturated water absorption test, acid resistance test, carbonation test etc are the tests conducted for the study. From the test the optimum percentage replacement of red mud with cement by weight was found to be 30% and it is due to the increased pozzolonic property of cement due to addition of red mud both in case of M20 and M40 grades of concrete. Strength results of 30% of red mud replacement shows almost same results of conventional concrete of respective M20 and M40 grade concrete. The addition of super plasticizer on M40 grade increased the workability of concrete. Use of red mud and hydrated lime in the production of concrete shows the same strength properties as in case of conventional concrete for both M20 and M40 grades. It was due to the presence of Al_2O_3 and SiO_2 in red mud and argillaceous content by hydrated lime.

K Deepika et.al (2017) conducted an experimental investigation of concrete by red mud as replacement of cement and using strengthening admixture. The admixture used was the conplast WL. The study was conducted on M20 grade concrete with 0%, 5%, 10%, 20% replacement with red mud. The tests conducted were compressive strength test, tensile strength test and flexural strength test. From the study, it was observed that 20% replacement of the red mud for cement was possible from compressive strength, split tensile strength and flexural strength. The strength result of 20% of red mud replacement concrete shows two fold strength increased in the M20 grade of concrete. Also found that the addition of admixture for M20 grade concrete increased the workability. The water absorption of concrete increased with increased percentage of red mud.

Sithar Pateliya, Chetan Solanki (2017) conducted experimental studies on concrete utilizing red mud as a partial replacement of cement. The mix proportions taken for the study was M20, M25 and M30 and the percentage replacement of red mud was 0%, 16%, 17%, 18%, 19%, 20%, 21%, 22%, 23% and 24%. The study was based on slump test, compressive strength test, flexural strength test, tensile strength test and durability test for M20, M25 and M30 grade. For M20 grade of concrete, optimum replacement of red mud was up to 18% for compressive strength, splitting tensile strength, flexural strength and durability. For both M25 and M30 grade concrete, the optimum value was up to 18% replacement of red mud.

3. MATERIALS

3.1 Cement

53 Grade Ordinary Portland Cement (OPC) provides high strength and durability to structures because of its optimum particle size distribution and superior crystallized structure. Being a high strength cement, it provides numerous advantages wherever concrete for special high strength application is required, such as in the construction of bridges, flyovers, chimneys, runways, concrete roads and other heavy load bearing structures. It is also more durable. A savings of 8-10% can be achieved with the use of 53 Grade OPC in place of any other grade.

3.2 Fine Aggregate

Manufactured sand (M-Sand) is a substitute of river sand for concrete construction. Manufactured sand is produced from hard granite stone by crushing. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most of the world. Due to the depletion of good quality river sand for the use of construction, the use of manufactured sand has been increased. Another reason for use of M-Sand is its availability and transportation cost. The other advantage of using M Sand is that it can be dust free, the sizes of M-Sand can be controlled easily so that it meets the required grading for the given construction.

3.3 Coarse Aggregate

Coarse aggregate of size 20mm was used. Aggregates are a component of composite materials such as concrete and asphalt concrete. The compressive aggregate strength is an important factor in the selection of aggregate. When determining the strength of normal concrete, most concrete aggregates are several times stronger than the other components in concrete and therefore not a factor in the strength of normal strength concrete. Light weight aggregate concrete may be more influenced by the compressive strength of aggregates.

3.4 Red Mud

Red mud is composed of a mixture of solid and metallic oxide-bearing impurities, and presents one of the aluminium industry's most important disposal problems. The red colour is caused by the oxidized iron present, which can make up to 60% of the mass of the red mud. In addition to iron, the other dominant particles include silica, unleached residual aluminium, and titanium oxide. Red mud cannot be disposed of easily. As a waste product of the Bayer process the mud is highly basic with a pH ranging from 10 to 13. The following is the composition of the dry red mud.

3.5 Water

Water is an important constituent in concrete. It is chemically reacts with cement to produce the desired properties of concrete. Strength and durability of concrete can be varied by its w/c ratio. The amount of water in concrete controls many fresh and hardened properties including workability, compressive strengths, permeability and water tightness, durability and weathering, drying shrinkage and potential for cracking. For these reasons, limiting and controlling the amount of water in concrete is important for both constructability and service life.

4. CONCRETE MIX DESIGN

Mix design of M20 grade concrete was calculated

Table-1: Mix Proportion

Cement	Fine Aggregate	Coarse Aggregate	Water Content
1	1.5	3	0.5

5. RESULT AND DISCUSSION

Result for workability and compressive strength of M20 grade concrete after 3 days, 7 days and 14 days were found out. The percentages of replacement of cement with red mud were taken as 0%, 5%, 10%, 15%.

5.1 Workability Test

Slump cone test is used for determining the workability of the concrete. It is the simplest workability test for concrete.

Table-2: Slump Result

Sl.No.	Percentage replacement of red mud	Slump (mm)
1	0	80
2	5	81
3	10	83
4	15	85

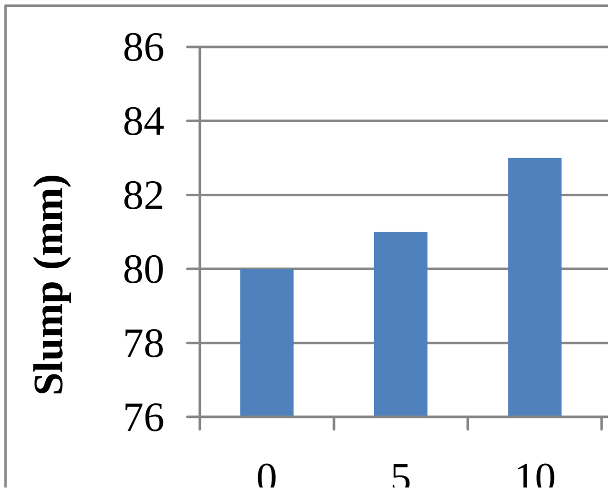

Chart-1: Slump Value

It is very essential for concrete to have good workability so that entrapped air can be easily removed by minimum effort of compaction. Here the slump value is increasing for different percentage of red mud i.e., the workability is increasing. It may be due to the decrease in bleeding and segregation amount.

5.2 Compressive Strength Test

Compressive strength is defined as resistance of concrete to axial cubes. Out of many test applied to the concrete this is the most important one which gives an idea about all the characteristics of concrete. By this single test one can judge that whether concreting has been done properly or not. Load at the failure divided by area of specimen gives the compressive strength of concrete. Compressive strength after 3 days, 7 days and 14 days was done for M20 grade concrete.

Table-3: Compressive Strength After 3 Days

Sl.No.	Percentage replacement of red mud	Compressive strength (N/mm^2)
1	0	9.33
2	5	10
3	10	10.88
4	15	10.22

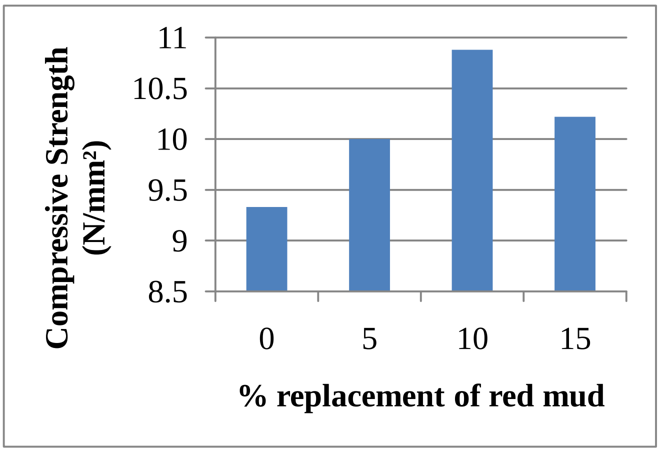

Chart-2: Compressive Strength After 3 Days

Table-4: Compressive Strength After 7 Days

Sl.No.	Percentage replacement of red mud	Compressive strength (N/mm^2)
1	0	13.7
2	5	14.4
3	10	15.1
4	15	11.1

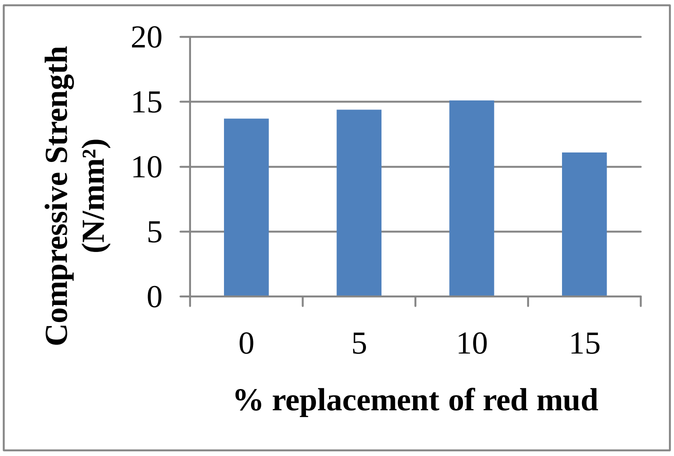

Chart-3: Compressive Strength After 7 Days

Table-5: Compressive Strength After 14 Days

Sl.No.	Percentage replacement of red mud	Compressive strength (N/mm^2)
1	0	17.1
2	5	18.8
3	10	20
4	15	17.7

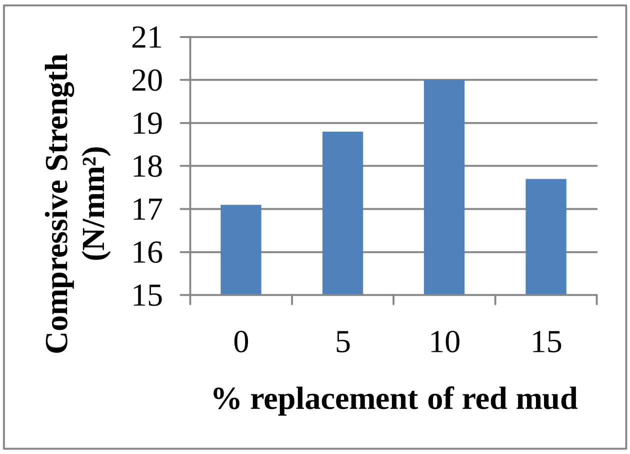

Chart-4: Compressive Strength After 14 Days

Charts show the compressive strength after 3 days, 7 days and 14 days for different percentage of red mud. For each percentage replacement up to 10% the compressive strength is increasing. But beyond 10% there is a reduction in the strength. This is because the red mud shows small capacity to fix the calcium ions that are present in the aqueous solution, suggesting low pozzolanic activity. Therefore from the experiment the optimum value obtained is 10%.

6. CONCLUSIONS

This project focuses on production of concrete using industrial waste like red mud. The red mud can be used for partial replacement of cement in concrete. The workability of concrete is seems to be increasing as the percentage of red mud increasing in the mix. For each percentage replacement up to 10% the compressive strength values of the red mud concrete is greater than that of conventional concrete. But beyond 10% there is a reduction in the strength of red mud concrete. This reduction in strength is because of red mud showing small capacity to fix the calcium ions that are present in the aqueous solution, suggesting low pozzolanic activity. Hence, the optimum percentage of the replacement of cement by weight is found to be 10%. By these results, replacement results got are similar to conventional concrete. Therefore, red mud can be effectively used as replacement material for cement and replacement enables the large utilization of waste product.

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