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# Performance of Concrete Utilizing Red Mud as a Partial Replacement of Cement with Hydrated Lime

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***Abstract*: Red mud is a strong waste buildup of the assimilation of bauxite metals with scathing soft drink for alumina generation. Its transfer remains an overall issue as far as ecological concerns. Amid the previous decades, broad work has been finished by a ton of scientists to create different financial routes for the usage of red mud. This paper gives a survey on the far reaching usage of red mud internationally. The exploration advancement of safe amassing of red mud is condensed. Gigantic amount of red mud is produced worldwide consistently representing an intense and disturbing ecological issue. This paper depicts the creation and portrayal of bauxite and red mud in perspective of World and Indian setting. It audits thoroughly the transfer and balance techniques for red mud and gives the nitty gritty evaluation of the work conveyed up to this point for the use of red mud in various fields. The concoction and mineralogical qualities of red mud are abridged with their natural concerns Project identifies with the supplanting of bond with red mud at certain rate i.e. 10%, 20%, 30% and with a steady level of hydrated lime (5%) the throwing work has been done of the block mould (150mm*150mm*150mm) and cylindrical shaped mould (150mm*300mm) and the consequence of 7 days and 28 days compressive quality has been discovered and which is been fruitful as of not long ago. What's more, to locate a proficient method to do it viably and discover the regions in which enhancement should be possible is the sole reason for our venture And by incompletely supplanting the red mud as solid constituents which results in a legitimate discard squander and an expansion in quality of cement and the effectiveness of the red mud as per cost and condition point of view too. Also, by supplanting the red mud and utilizing it as a basic material it gives expanded quality and less transfer of red mud in the earth which results in lesser contamination and diminished natural risks.**

***Keywords*: Cement mortars, Red mud, hydrated lime, compressive strength.**

## 1. Introduction

Concrete can be portrayed as the material with a cement properties which make it able to make holding between two sections into a minimized mass. This definition envelops a huge assortment of establishing material. For constructional purposes the importance of the term concrete is confined to holding material utilized with stones, block, and squares and so on. Bond is the most critical material in auxiliary development at it is utilized at various phases of development in type of mortar and cement. In the most recent decade , the creation of aluminum notwithstanding some staleness and set back periods have demonstrated an investigation ascent of about 1%. The biological results of aluminum creation are outstanding; compromising of surface and underground water and air contamination by waste gases from aluminum electrolysis plant and moving factories. The level of harm caused to ground water and air amid the single generation stages from bauxite to aluminum relies upon two or three actuality of which those associated with the alumina extraction and red mud transfer.

### *A. Red mud*

Red mud is the iron rich buildup from the assimilation of bauxite. It is one of the major side-effect originating from Bayer procedure of alumina generation. All in all, around 2 - 4 tons of bauxite required for creation of every ton of alumina Al2O3 and around one ton is produced. Since the red mud is created in mass it must be put away in huge limited and impenetrable lakes, in this way the bauxite refining is steadily circled by the capacity lake. At present around 60 million tones of red mud is produced yearly overall which isn't being arranged or reused agreeably.

## 2. Review literature

An Overview of Chemical Process To Manufacture Red Mud Construction Products. Real stores of red mud are in profoundly populated developing monetary areas. Reusing red mud as development materials is essential to these nations for monetary. Room-temperature setting substance responses to harden red mud into development items might be one approach to reuse red mud. In this procedure, we exploited high substance of iron oxide (hematite) in red mud, and somewhat decreased a little segment of it to start initiation response with a corrosive phosphate. This procedure produces fast setting elective red mud bond that can be utilized to make solid, blocks, and building squares. The two procedures have been demonstrated and utilized in different fields.

### *A. Strength of red mud*

It is obvious from the writing overview that red mud expands the qualities of cement to an impressive degree. It decreases the fine pores of cement and consequently lessens penetrability.

Red mud's pH esteem changes from 10 to 12 and because of which it anticipates consumption of support.

### *B. Weaknesses of red mud*

Because of its high alkalinity it harms agrarian terrains, for arranging it ought to be washed multiple times. There are odds of spillages from red mud lake. It defiles the ground water table on the off chance that it is arranged underground based on writing overview, it is clear that red mud fills in as a decent folio material and has turned out to be a decent cementations material. Red mud diminishes the fine pores of cement and subsequently as the level of red mud in solid increments there is a resulting decline in the level of water ingested. A basic blending of 70% red mud and 30% CaO gives an item with compressive quality of 7MPa. The hydrates framed following 4 days are $Ca(OH)_2$ C4AH13 and C4AH11. These outcomes have been affirmed by later examinations. Red mud does not confer much compressive quality when contrasted with fly powder, however it has been seen that flexural quality and protection from porousness increments in red mud bond concrete. In spite of the fact that utilizing red mud is less attainable than utilizing fly fiery remains yet it is important to utilize or reuse red mud as it has numerous unsafe ecological impacts.

### *C. Use of red mud as raw material*

Past uses of red mud in the creation of clinker and composite bonds, another intriguing course for the use of red mud in the concrete business is the arrangement of soluble base initiated concrete. Dish et al. (2002, 2003) led an examination of utilizing sintering process red mud, impact heater slag and strong soluble base activator, for example, strong water glass and sodium aluminate clinkers to deliver salt initiated bond. This sort of soluble base enacted concrete has a place with without clinker cementitious material. They detailed that the antacid initiated red mud– slag concrete had high compressive quality (56MPa at 28 days and 65 MPa at 90 days) and fantastic obstruction against compound assaults and freezing– defrosting cycles, principally due to the denser microstructure and lower add up to porosity in the hydrated glue in examination with those of the reference PPC glue.

## 3. Objective of the study

The significant destinations of this investigation were:

- The utilization of modern result instead of traditional crude materials will diminish the ecological contamination and furthermore moderate our common assets.
- The improvement of substitute ease and environmentally appropriate building materials from farming and mechanical result is a financial need.
- To recognize different mechanical side-effect reasonable for usage in bond fabricate.
- To inspect the requirements identified with usage of modern waste. Current interest of bond is far in overabundance of generation and is quickly expanding

### *A. Materials Used Ordinary pozzolana cement*

Common pozzolana concrete affirming to IS: 269-1976 was utilized all through the examination. The different tests were performed on the cement to ensure that it confirms to the requirements of the IS specifications. The physical and chemical properties of the cement were determined as per IS: 4031-1968 and are presented in Table 1 & 2.

Table 1
Physical properties of cement

| S.NO | Characteristics | Values |
|---|---|---|
| 1 | Standard consistency | 34 |
| 2 | Fineness of cement as retained on 90 micron sieve | 7% |
| | | |
| 3 | Initial setting time | 27 minutes |
| 4 | Specific gravity | 3.14 |
| 5 | Compressive strength (in 7days) | 38 MPa |

Table 2
Chemical Properties of Cement

| S.NO | Components | | Weight |
|---|---|---|---|
| | | | |
| 1 | Lime (CaO) | | 63% |
| | | | |
| 2 | Silica (SiO2) | | 22% |
| 3 | Alumina (Al2O3) | | 6% |
| 4 | Iron oxide (Fe2O3) | | 3% |
| 5 | Magnesium oxide (MgO) | | 2.5% |
| | | | |
| 6 | Sulphur trioxide & loss of | | 1.5% |
| | ignition (SO3) | | |
| 7 | Alkalies | | 0.5% |

### *B. Red Mud*

The attributes of Red mud rely upon the idea of the bauxite metal utilized. Dicalcium silicate in red mud is likewise one of the primary stages in bond clinker. Researchers led a progression of concentrates into the creation of bond utilizing red mud, fly fiery remains, lime and gypsum as crude materials. Utilization of red mud concrete not just diminishes the vitality utilization of bond generation, yet in addition enhances the early quality of bond and protection from sulfate assault.

### *C. Composition of red mud*

Red mud is made out of a blend of strong and metallic oxide-bearing contaminations, and presents one of the aluminum business' most critical transfer issues. The red shading is caused by the oxidized iron present, which can make up to 60% of the mass of the red mud. Notwithstanding iron, the other predominant particles incorporate silica, unleached left over aluminum, and titanium oxide.

Table 3
Chemical properties of the dry red mud

| **Compound** | Al2O3 | SiO2 | Fe2O3 | TiO2 | CaO | V2O5 | MgO | ZnO | Na2O | P2O5 | MnO | K2O | L.O.I |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Weight (%)** | 15.64 | 12.86 | 50.26 | 5.16 | 4.09 | 0.116 | 0.043 | 0.031 | 8.20 | 0.301 | 0.181 | 0.055 | 7.43 |

Fig. 1. Red mud

Table 4
Characteristics of red mud

| **S. No.** | **Property** | **Value** |
|---|---|---|
| 1 | Specific gravity | 3.11 |
| 2 | pH | 10-12.5 |
| 3 | Maximum dry Density (g/cc) | 1.25 |
| 4 | Cohesion (kg/cm$^2$ ) | 0.129 |
| 5 | Angle of internal friction(in Degree's) | 26.3 |

### *D. Hydrated lime*

The hydrated lime essentially comprise of lime i.e. CaOH which is for the most part included with and bond Red mud as it contains segments that in blend with lime create calcium aluminates hydrates. These response items can create quality. Consequently with the end goal of prudent development and for expanding the mechanical properties of solid red mud has ended up being powerful in all regards.

Table 5
Chemical properties of hydrated lime

| **Constitutes** | **Composition (in %)** |
|---|---|
| Silica (as SiO2 ) | 0.45 |
| Iron as $Fe_2O_3$ | 0.07 |
| Aluminium as $AI_2O_3$ | 0.08 |
| Calcium Oxide | 73.03 |
| Magnesium Oxide | 0.92 |
| Available lime as CaO | 71.97 |
| Available lime as $Ca(OH)_2$ | 80.00 |
| Carbon Dioxide | 0.81 |
| Lead | < 5ppm |
| Arsenic, Chromium | <0.001% |
| Cadium, Barium | <0.001% |
| Copper | 0.02% |

### *E. Coarse aggregate*

Table 6
Coarse aggregate size

| **Coarse aggregate** | **Size** |
|---|---|
| Fine gravel | 4mm – 8mm |
| Medium gravel | 8mm – 16mm |
| Coarse gravel | 16mm – 64mm |
| Cobbles | 64mm – 256mm |
| Boulders | >256mm |

When the total aggregate material is sieved through 4.75mm IS sieve, the aggregate retained on 4.75mm IS sieve, is called coarse aggregate. For examples: gravel, cobble and boulders. The maximum size aggregate used may be generally from 10 mm to 20mm. In general, 20 mm size is used for high strength concrete. The specific gravity of coarse aggregate is 2.70.

### *F. Fine aggregate*

When the total aggregate is sieved through 4.75mm IS sieve, the aggregate passed through 4.75mm IS sieve, is called fine aggregate. Generally natural sands are used as fine aggregate, but also silt and clay come under this category. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

Table 7
Properties of fine aggregate

| **Property** | **Value** |
|---|---|
| Specific gravity | 2.70 |
| water absorption | 2% |
| Silt content | 5% |

### *G. Water*

The water used in the mix design was potable drinking water, locally available and it's free from organic materials and suspended solids, which might have affected the properties of the fresh and hardened concrete.

### *H. Concrete mix*

The cement is blended with 5% of hydrated lime and replaced by 0%, 10%, 20% and 30% on the weight by neutralized red mud. At the time of mixing, the water cement ratio is kept constant throughout the mixing process. After proper mixing of all the constituents with their respective proportions, the concrete of three design mix of grade M30 was prepared. And all the concrete mix was studied for the compressive.

Table 8
Concrete design mix proportions

| **Cement** | **Sand** | **Aggregate** | **w/c ratio** |
|---|---|---|---|
| 1 | 1.59 | 2.74 | 0.45 |

### *I. Mix proportions*

Cement = 425.73 kg/m$^3$
Water = 191.58 kg/m$^3$
Fine aggregate = 678.113 kg/m$^3$
Coarse aggregates = 1169.31 kg/m$^3$

Table 9
Replacement of red mud in percentage of cement weight (%)

| Replacement of red mud (in %) | 0 | 10 | 20 | 30 |
|---|---|---|---|---|

## 4. Guidelines

### *A. Compressive strength test*

Compression test is carried out on specimen of the size 150mm x150mm x 150mm in all dimensions. Concrete mix is

M-30 and have the proportion of 1:1.59:2.74 in ratio of cement, sand, aggregate. There are replacement of cement 0%, 10%, 20%, 30% with red mud respectively. The three cubes are made with different replacement value. Concrete is poured into the moulds in three layers and each layer was tamped with twenty five strokes of the tamping rod and then put on a vibrator table so as to remove voids. The top surface is finished using trowel and is kept for 24 hours. After completion of 24 hours concrete cubes are detached from the mould and the specimens are kept in water for curing. Cubes are tested under compression testing machine to get the compressive strength of concrete for 7 days and 28 days. The compression strength cube is calculated by using the following formula,

$$fc = P/A$$

Where,

fc = Cube Compressive strength in N/mm$^2$ (MPa),

P = Cube Compressive load causing failure in kN,

A = Cross sectional area of cube in mm$^2$


Fig. 2. Cube casting

Table 10
Compressive strength test result at 7 days

| Grade of Concrete | % of red mud used | % of hydrated lime | Compressive strength (in MPa) |
|---|---|---|---|
| M30 | 0 | 5 | 21.09 |
| | 10 | 5 | 25.36 |
| | 20 | 5 | 24.63 |
| | 30 | 5 | 21.53 |

The compressive strength test results showed that the upto 10% of red mud replacement with cement and 5% of hydrated lime gives ultimate compressive strength at 7 days.

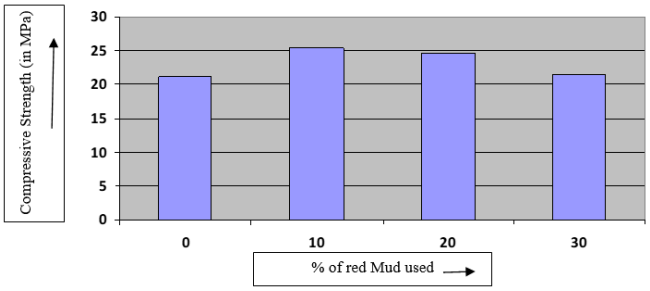


Fig. 3. Graph between compressive strength at 7 days versus % of red mud used

Table 11
Compressive strength test result at 28 days

| Grade of Concrete | % of red mud used | % of hydrated lime | Compressive strength (in MPa) |
|---|---|---|---|
| M30 | 0 | 5 | 33.50 |
| | 10 | 5 | 36.47 |
| | 20 | 5 | 34.26 |
| | 30 | 5 | 31.78 |

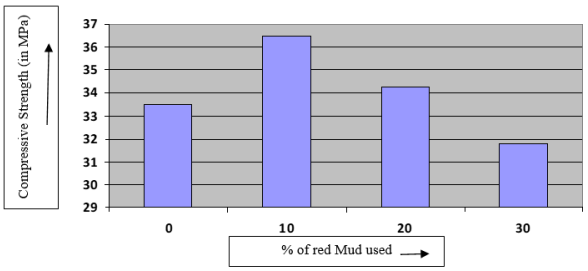


Fig. 4. Graph between compressive strength at 28 days versus % of red mud used


Fig. 5. Cube testing

The compressive strength test results showed that the upto 10% of red mud replacement with cement and 5% of hydrated lime gives ultimate compressive strength at 28 days.

### *B. Split tensile strength test*

Tensile test is carried out on a cylindrical specimen of dimension 1500x300 mm. Concrete mix is M30 and have the proportion of 1: 1.59: 2.74 in ratio of cement, sand, aggregate. There are replacement of cement 0%, 10%, 20%, 30% with red mud respectively. Three cubes are made with different replacement value. Cylindrical moulds are tested under compression testing machine to get the tensile strength of concrete for 7 days and 28 days.

The tensile strength is calculated by using the formula,

$T = 2P/\pi LD$ Where,

T = Tensile strength of concrete (in N/mm$^2$)

L = Length of cylinder

D = Diameter of cylinder

P = Load causing failure on concrete (in kN)

Table 12
Split tensile strength test result at 7 days

| Grade of Concrete | % of red mud used | % of hydrated lime | Tensile strength (in MPa) |
|---|---|---|---|
| M30 | 0 | 5 | 2.18 |
| | 10 | 5 | 2.67 |
| | 20 | 5 | 2.20 |
| | 30 | 5 | 2.18 |

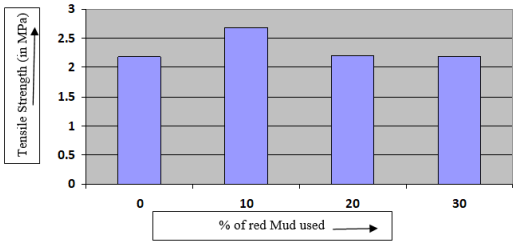


Fig. 6. Graph between Split Tensile Strength at 7 days versus % of red mud used

The Split Tensile results test showed that the upto 10% of red mud replacement with cement and 5% of hydrated lime gives ultimate Split Tensile strength at 7 days.

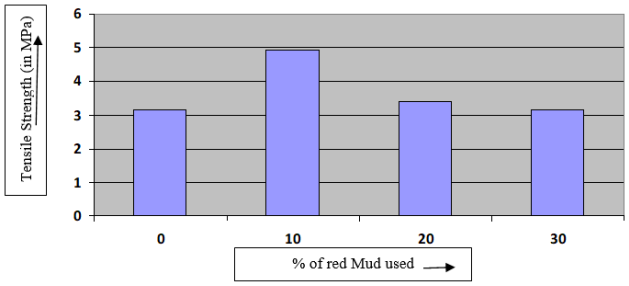


Fig. 7. Graph between Split Tensile Strength at 28 days versus % of red mud used

Table 12
Split tensile strength test result at 28 days

| Grade of Concrete | % of red mud used | % of hydrated lime | Tensile strength (in MPa) |
|---|---|---|---|
| M30 | 0 | 5 | 2.18 |
| | 10 | 5 | 2.67 |
| | 20 | 5 | 2.20 |
| | 30 | 5 | 2.18 |

The split tensile strength of cylindrical specimen's results also indicated that the addition of red mud yielded comparable strength with that of control cylindrical specimens. The optimum value of split tensile strength was obtained at the 10% replacement of cement by neutralized red mud with addition of 5 % of hydrated lime. Finally, the Split Tensile test results showed that the upto 10% of red mud replacement with cement and 5% of hydrated lime gives ultimate Split Tensile strength at 28 days

## 5. Conclusion

From this experimental study following points will be drawn:

- After testing of 3 blended cement samples (10% to 30 % replacement of Cement by RM) with an increment of 10 %, it can be said that the optimum use of RM is 10% as a partial replacement of cement by RM with addition of 5% hydrated lime.
- The cost of M 30 grade RM Concrete (i.e. 10 % Replacement) is around 7.48 % less than the Conventional Concrete, with an increase up to 21.712 % in the 28 days Compressive strength.
- The percentage economy is increased with the increase in the grade of concrete but at the same time there is a reduction in the percentage increase in the Compressive Strength.
- Considering all the above point it is interesting to say that the optimum utilization of red Mud in concrete is 10 % as a partial replacement of cement by Red Mud. It is also be utilized as a replacement material for cement and utilization of waste product.
- Red mud did not affect the cement properties, rather improved the cement quality by reducing the setting time & improved compressive strength.
- Used for road construction as an embankment landfill is an attractive option with a high potential for large volume reuse.
- Replacement of 10% OPC by calcined red mud is thus possible. Calcinations of red mud at 7000C leads to a pozzolanic material essentially reactive at early ages.
- This thermal treatment changes the phase composition of the material, mainly by promoting the elimination of hydrated phases and improves its amorphous character.
- Physical parameters of red mud are affected by calcinations process, the surface area and the unitary mass decrease and the specific gravity increases;
- The results of pozzolanic activity by chemical and physical methods were very satisfactory and indicate the feasibility of red mud use as a pozzolana, in addition to Portland cement.

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